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DEPARTMENT OF' TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

VOR/DME EQUIPMENT
PART 1 - GENERAL REQUIREMENTS

This is Part 1 of a nine part group of specification documents under the basic heading "VOR/DME Equipment" which covers the requirements for FAA VOR and DME facilities, including Remote Maintenance Monitoring (RMM) and Remote Maintenance Control (RMC) of facility performance.

Each document carries the basic number FAA-E-2678 together with an alpha revision letter and a slant line and number corresponding to the part number (see listing below). Each part should be separately referenced by its individual specification number and any amendment which is applicable to the individual part.

Listing of Parts

FAA-E-2678c/1	Part 1	General Requirements
FAA-E-2678c/2	Part 2	Battery Charger Power Supply (BCPS)
FAA-E-2678c/3	Part 3	Facility Central Processing Unit (FCPU)
FAA-E-2678c/4	Part 4	VOR Transmitter Equipment
FAA-E-2678c/5	Part 5	VOR Monitor Equipment
FAA-E-2678c/6	Part 6	DME Transponder Equipment
FAA-E-2678c/7	Part 7	DME Monitor Equipment
FAA-E-2678c/8	Part 8	Doppler VOR Conversion Kit
FAA-E-2678c/9	Part 9	Remote Status and Communications Equipment (RSCE)

1-1 SCOPE - GENERAL REQUIREMENTS

1-1.1 Scope of Part 1.- This specification establishes the performance, design, test, manufacture, and acceptance requirements for the FAA VOR/DME systems, including remote maintenance monitoring and control of facility performance. This equipment will expand the current enroute and terminal navigation system through the establishment of new facilities.

1-1.2 Classification.- One type of facility is covered by this specification.

1-1.2.1 Type.- The type of facility is the VOR/DME.

1-2 APPLICABLE DOCUMENTS

1-2.1 Government documents.- The following documents of the issue in effect on the date of invitation for bids or requests for proposal form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superceding requirement.

1-2.1.1 FAA specifications.-

FAA-D-2494	Technical Instruction Book Manuscript: Electronic, Electrical and Mechanical Equipment, Requirements for Preparation of Manuscript and Production of Books
FAA-E-163	Rack, Cabinet, and Open Frame Types
FAA-E-1069	Reinforced Plastic Antenna Shelter (16' VOR/VORTAC)
FAA-G-1375	Spare Parts peculiar for Electronic, Electrical and Mechanical Equipment
FAA-G-2100	Electronic Equipment, General Requirements
FAA-G-2300	Panel and Vertical Chassis, Rack

1-2.1.2 Military specifications.-

MIL-C-5541	Chemical Conversion Coatings on Aluminum and Aluminum Alloys

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MIL-STD-470	Maintainability Program Requirements (For Systems and Equipments)
MIL-STD-471	Maintainability Demonstration
MIL-STD-472	Maintainability Prediction
MIL-STD-721	Definitions of Effectiveness Terms for Reliability, Maintainability, Human Factors and Safety
MIL-STD-781	Reliability Tests, Exponential Distribution
MIL-STD-785	Reliability Program for Systems and Equipment Development and Production
MIL-STD-810	Environmental Test Methods
MIL-STD-1189	Bar Coding Symbology
MIL-STD-1388-1A	Logistics Support Analysis
MIL-STD-1388-2A	Logistics Support Analysis Record
MIL-STD-1521	Technical Reviews and Audits for Systems, Equipments and Computer Programs
MIL-STD-1561	Uniform DOD Provisioning Procedures

1-2.1.5 Federal standards.-

FED-STD-595	Colors

1-2.1.6 Other publications.- The following publications of the issue in effect on the date of the invitation for bids or request for proposals form a part of this specification and are applicable to the extent specified herein.

FAA Interface Control Documents

NAS-MD-790	Remote Maintenance Monitoring Interface Control Document
NAS-MD-792	Operational Requirements for the Remote Maintenance Monitoring System (RMMS)

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MIL-STD-785	Reliability Program for Systems and Equipment Development and Production
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NAS-MD-792	Operational Requirements for the Remote Maintenance Monitoring System (**RMMS**)

ANSI-X3.66	American National Standard for Advanced Data Communications Control Procedures (ADCCP)
EIA-RS-232-C	Interface Between Data Terminal Equipment and Data Communication Equipment Employing Serial Binary Data Interchange

1-2.2.1.1 Obtaining industry documents.- Requests for information on obtaining copies of ANSI publications should be directed to American National Standards Institute, 1430 Broadway, New York, New York, 10018. Requests for information on obtaining copies of EIA publications should be directed to Electronic Industries Association, 2001 Eye Street, N.W., Washington, DC, 20006.

1-3 REQUIREMENTS

1-3.1 Definitions.-

1-3.1.1 VOR.- (Spoken as three letters.) Stands for VHF Omnidirectional Range. An air navigation system operating in the band of 108 to 118 MHz. VOR provides suitably equipped aircraft with bearing information to or from a fixed ground station. VOR is the U.S. and International Civil Aviation Organization standard for bearing information for short distance navigation. The term VOR is also used to designate the ground station which radiates the VOR signal.

1-3.1.2 DME.- (Spoken as three letters). Stands for Distance Measuring Equipment. An air navigation system operating in the frequency range of 962 to 1213 MHz. DME provides suitably equipped aircraft with information of distance to a fixed ground station. DME is the U.S. and International Civil Aviation Organization standard for distance information for short distance.

1-3.1.3 VOR/DME.- A fixed ground station which provides both VOR and DME information to aircraft thereby allowing for a geographical fix.

1-3.1.4 Facility.- The term facility as used in this specification is limited to a VOR/DME ground station.

1-3.1.5 Local.- As used in this specification, local refers to the facility premises.

1-3.1.6 Remote.- As used in this specification, remote refers to any location, either an operational or maintenance monitoring or control point, other than the facility location.

1-3.1.7 Remote communications outlet (RCO).- A VHF communications receiver often located at a facility. Used in conjunction with voice transmissions on the VOR to provide air-to-ground communication. ("Remote" in this instance is used in the opposite sense to that defined in 1-3.1.6.)

1-3.1.8 Operator/operational.- As used in this specification these terms refer to Air Traffic Control (ATC) personnel or to Flight Service Station (FSS) personnel or to the use of the facility by such personnel for purposes of air traffic control.

1-3.1.9 Technician.- The individual charged with responsibility for the technical performance of the facility. Assigned tasks include certification of technical performance, preventive, and corrective maintenance.

1-3.1.10 Monitor/monitoring.- Both terms refer to knowledge of the status and performance of a facility. The term "monitor" as used in this specification refers to an equipment or system. "Monitoring" refers to the complete process and includes the subsequent actions taken in response to the information provided. The monitoring process may include a human element.

1-3.1.10.1 Operational monitoring.- The information provided for operational monitoring includes notification of malfunction or failure (alarm indicators), identification of the operating equipment, and emergency warnings such as fire or intrusion alarms. Information for operational monitoring is of a qualitative rather than quantitative nature. The information is, however, required to be continuous with notification of changes provided almost instantaneously.

1-3.1.10.2 Maintenance monitoring.- The information provided for maintenance monitoring consists of quantitative data on the actual performance and/or status of the facility including any individual elements thereof. This data may be used for facility certification, trend analysis, or fault isolation purposes. The transmittal of maintenance monitoring data is not required to be continuous but may be programmed to be periodically transmitted, transmitted upon occasion of faults, or transmitted on request. Maintenance monitoring also includes the ability to control facility operational, ancillary, and test equipment for testing the operational capability, verifying monitor alarm limits, and changing the operational characteristics of equipment.

1-3.1.10.2.1 Facility certification.- Periodic measurement and recording of system performance, including radiated signal characteristics, monitor alarm limits, and the test of automatic shutdown operation to certify proper facility operation.

1-3.1.10.2.2 Trend analysis.- Measurement and monitoring of in-circuit parameters for identifying and possibly preventing equipment or system failures. This data shall be collectable and transferable.

1-3.1.10.2.3 Fault isolation.- Automatic isolation of an equipment fault to the lowest specified level of component replacement. (Note: fault isolation is not limited to faults producing a fault condition in the monitor; see paragraph 1-3.1.10.4.)

1-3.1.10.3 Executive monitor.- A device which continuously examines key parameters of the output signals of the facility/equipment, provides for shutdown of equipment when these signal characteristics are found to be outside of pre-established tolerances, and simultaneously initiates local and remote alarm indications. In normal unattended operation of the facility these actions are automatic.

1-3.1.10.4 Fault condition.- The condition where a monitor senses that one or more parameters of the output signals are outside of pre-established tolerances.

1-3.1.10.5 Alarm condition.- A condition which results when a fault (1-3.1.10.4) has existed for a pre-established period of time. Alarm results in the action described under 1-3.1.10.3.

1-3.1.10.6 Monitor "fail safe".- A principle which states that a failure in the executive monitor itself must result in an alarm (1-3.1.10.5).

1-3.1.10.7 Monitor "happy".- The condition where the executive monitor senses that the monitored signal parameters are within established tolerances and provides local and remote indication of normal operation.

1-3.1.10.8 Monitor "unhappy".- Same as fault condition (1-3.1.10.4).

1-3.1.10.9 Monitor "bypass".- A feature which allows a technician to override the normal functions of the executive monitor to permit operation of an equipment for troubleshooting purposes.

1-3.1.11 Operating transmitter/transponder.- A transmitter/transponder which is energized and radiating signal(s) through the ground station antenna.

1-3.1.12 Module.- Two or more parts which form a portion of an assembly or a unit replaceable as a whole but having parts which are individually replaceable.

1-3.1.13 Shutdown.- The condition wherein neither transmitter/transponder is radiating signal(s).

<u>1-3.1.14 Automatic operation.</u>- Refers to normal unattended operation of a transmitter/transponder and associated equipment under control of the executive monitor (1-3.1.10.3). In this mode of operation the transmitter/transponder remains in operation until the executive monitor senses an alarm, whereupon the transmitter/transponder is deenergized. The system shall automatically reenergize (auto-reset) when the alarm is transient.

<u>1-3.1.15 Remote control.</u>- Includes all functions specified to be provided to operations or maintenance personnel from a remote location through access to the Facility Central Processing Unit (FCPU). These functions include control of facility ancillary equipment not furnished under this specification. Relative to paragraph 1-3.1.14, remote control includes the ability to shutdown, restart, and to select the initially operating equipment. Those functions controllable locally through the FCPU shall also be controllable remotely through the FCPU.

<u>1-3.1.16 Local control.</u>- Includes all functions under 1-3.1.15 above provided to the local technician through direct access to the FCPU. In addition, includes the ability to manually override or bypass automatic operation (1-3.1.14) and otherwise permit operation of equipment independently upon failure of the FCPU.

<u>1-3.1.17 "Fail-soft".</u>- A concept wherein one or more elements in a design may fail resulting in a lesser, but still operationally usable, level of performance. One example is failure of certain portions of the DME final amplifiers affecting only the transmitted power of the facility. In this event, the non-failed portion of the amplifier remains in operation providing DME service at reduced power (subject to specified limits).

<u>1-3.1.18 Reliability.</u>- The term reliability as used herein refers to the mean time between failure (MTBF) of any portion of an equipment which provide any specified function. Reliability does not include those features or elements or an equipment provided solely for local maintenance purposes (e.g., panel meters, indicator lamps, PMDT, etc.).

<u>1-3.1.19 Unit.</u>- A functional assembly of components and modules.

<u>1-3.1.20 Line replaceable unit (LRU).</u>- An item which may consist of a unit, an assembly (circuit card assembly, electronic component assembly, etc.) a subassembly, or a part, that is removed and replaced at the site maintenance level in order to restore the system/equipment to its operational status.

<u>1-3.1.21 Failure.</u> - The inability of any part, circuit, assembly, or unit of the VOR/DME to operate within its normal and previously established operating tolerances shall constitute a

failure. It shall be specifically noted that it is not necessary that a maintenance action be required or a station outage result because of a failure.

1-3.2 Equipment/software/services to be furnished by the contractor.- Each set of equipment shall be complete including operational software in accordance with all specification requirements and shall include the items tabulated below. Each set of equipment shall be completely wired and ready for operation upon connections of AC or DC power, external control cables, and external antenna cables. Each set of equipment shall be tuned, adjusted and production tested for operation on a channel assigned in accordance with the provisions contained in the contract schedule prior to shipment. (See Table 1 for channel frequencies and pairings.)

Each VOR/DME equipment set shall consist of the following functional elements:

	Elements	quantity/set
1.	Battery Conditioner Power Supply (BCPS)	1
2.	Facility Central Processor Unit (FCPU) and associated modems	1
3.	VOR Transmitter	1
4.	VOR Monitor	2
5.	VOR Monitor Antennas	(16)
6.	DME Transponder	1
7.	DME Monitor	
8.	Remote Status and Communications Equipment (RSCE) and associated modems	1
9.	All required operational and maintenance software	1

1-3.3 Equipment characteristics.- The subparagraphs below contain requirements applicable to all equipment items required by contract referencing this specification.

1-3.3.1 Equipment physical design and packaging.- The equipment shall be designed, configured, and packaged in such a manner as to facilitate the accomplishment via either front, side or top access of all test, adjustment, and maintenance operations. All of the equipment components provided for installation at the facility location shall be housed in not more than three cabinets (1-3.3.1.1). All unused front panel space shall be covered by blank panels. Front panels provided for access to cabinet main frame terminal boards shall be mounted by means of quick-disconnect fasteners.

1-3.3.1.1 Equipment cabinet.- The VOR/DME electronic units shall be housed in aluminum or steel cabinet(s) designed to be mounted inside an existing Government furnished equipment failure. It shall be specifically noted that it is not necessary that a maintenance action be required or a station outage result because of a failure.

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<u>1-3.3.1.1 Equipment cabinet.</u>- The VOR/DME electronic units shall be housed in aluminum or steel cabinet(s) designed to be mounted inside an existing Government furnished equipment

printed wiring board(s), plug-in subchassis or chassis-type module(s) in accordance with specification requirements.

1-3.3.1.6 RF modules.- RF modules shall be printed wiring boards except where such practice is not consistent with circuit performance requirements (see paragraph 1-3.3.1.7). RF modules shall be plug-in except that feed through screw type connectors may be used for RF interconnection. Tuning controls (see paragraph 1-3.3.13) shall be readily accessible when the modules are in place. Where necessary to provide unrestricted access to all components for troubleshooting purposes, extender cable(s) shall be furnished. A minimum of one extender cable of each type required shall be furnished. Extender cables shall be stored within the equipment.

1-3.3.1.7 Chassis-type modules.- Chassis-type modules shall be used where printed wiring boards are impractical. A minimum of one extender cable for each type required shall be furnished and stored within the equipment.

1-3.3.2 Parts.- Parts selection, application, use and orientation shall be in accordance with paragraphs 3.5 through 3.5.7.2 of Specification FAA-G-2100.

1-3.3.3 Equipment finishes.- The finish of the equipment shall be as specified in paragraphs 3.7.6 through 3.7.6.5 of Specification FAA-G-2100 except that paragraph 3.7.6.1.2 is modified to require surface preparation and application of the primer in accordance with FAA-STD-012. Following application of the primer, the surface shall receive one or more uniform spray coats of a semigloss baking enamel in accordance with Federal Specification TT-E-529 and the color of the final coat shall be Color number 26044 of Federal Standard 595.

1-3.3.4 Reference designations and markings.- Reference designations and markings shall be in accordance with paragraphs 3.8 and 3.9 through 3.9.5.2, respectively, of Specification FAA-G-2100. In addition to the panel marking methods of paragraph 3.9.3.2, the use of silk screen markings is permissible on panel surfaces.

1-3.3.5 Nameplates.- Nameplates shall be in accordance with paragraphs 3.10 through 3.10.3 of Specification FAA-G-2100.

1-3.3.6 Interchangeability.- The VOR/DME equipment design shall incorporate the interchangeability requirements of paragraphs 3.5.4 through 3.5.4.3 of Specification FAA-G-2100.

1-3.3.7 Test points, connectors and fault diagnostics.- Each line replaceable unit (LRU) of the VOR/DME equipment shall contain test points, test facilities and connectors, appropriately labeled and numbered, to provide for the examination of essential voltages, signal amplitudes, waveforms and timing characteristics and to provide for the connection of test equipment for troubleshooting, adjustment and maintenance operations. Test points for all units employing microprocessors shall include all data, address and control signals. The VOR/DME shall have a central diagnostic function that shall initiate, log results and provide for the display of diagnostic results at the MPS or PMDT interface if a terminal is connected. The diagnostic routine shall be able to localize 85% of all failure occurrences to a single faulty LRU (see paragraph 1-3.1.20) and 95 percent of all failure occurrences to no more than two candidate LRUs, one of which contains the faulty element. The diagnostic routine shall be automatically initiated when an alarm or alert occurs except when the condition is the result of an environmental sensor parameter of paragraph 3-3.3.2.10.1 through 3-3.3.2.10.5 herein. Additional manually initiated diagnostics shall be available from the PMDT in local mode or from the MPS to offer more detailed information to aid in the maintenance process. The results of the automatic diagnostic routine shall be stored in memory at the facility RMS until reset at the PMDT interface or from the MPS. When the diagnostic routine is automatically initiated due to an alarm or alert, the entire routine shall be run to ensure that all failures have been identified.

<u>1-3.3.7.1 Location.-</u> Test points on plug-in printed wiring boards shall be located on the outside edge of the board. Printed edge connectors may be used for test points.

<u>1-3.3.7.2 Adapters.-</u> If edge board connectors are used, a minimum of two connector test adapters shall be furnished with each system to facilitate connection of test probes to the printed edge connections. Storage shall be provided within the cabinets for all adapters and connectors.

<u>1-3.3.8 Reset switch.-</u> Each unit of the VOR/DME equipment that employs microprocessors shall have a front panel mounted, momentary contact switch labeled "RESET". Activation of the reset switch shall cause all program variables and all software/firmware controlled hardware to be initialized to a predefined condition from which normal program execution can continue.

<u>1-3.3.9 Non-volatile memory.-</u> There shall be non-volatile memory(s) provided. The executive/operating program shall be in read-only memory (ROM). The working/data storage program memory(s) shall have at least three months of non-volatility. There shall be storage in non-volatile memory(s) of current status data of all monitored transmitter and transponder parameters and the upper and lower monitor fault/threshold alarm limits, also last routine sample data, and post-fault (but prior

to alarm) data. Stored data shall be available via polling or request.

__1-3.3.9.1 Volatile memory.-__ Scratch-pad memory, which may be erased upon power-on restart, may be volatile. Read-only memory (ROM), which contains site peculiar data, shall be plug-in circuitry located in associated sockets.

__1-3.3.10 Output circuit protection.-__ All equipment output circuits and transmitter output circuits shall be protected in accordance with the requirements of paragraph 3.3.2.2 of Specification FAA-G-2100.

__1-3.3.11 Printed wiring and printed wiring boards.-__ All printed wiring boards, except strip line, shall be of the plug-in card type and shall be mechanically coded and keyed in such a manner that only properly coded boards can be inserted. For purposes of this specification, strip line devices are classed as printed wiring.

__1-3.3.12 Cross-talk, shielding, and isolation.-__ The arrangement of parts and wiring and the design of the equipment shall be such that cross-talk and unnecessary coupling between circuits cannot result in conditions of operation which are beyond the values allowed for the specified performance characteristics. Adequate shielding and other means of isolation shall be provided as necessary to prevent the occurrence of significant changes in signal levels, waveforms, timing, tuning, or operating conditions with any combination of open access doors, withdrawn chassis, or with printed wiring extender boards (1-3.3.1.4) in use. Also the positioning of wires or cables shall not affect the operating conditions or performance of the equipment. In addition to the aforementioned requirements, sufficient shielding shall be provided to prevent interference from existing facility communication transmitter equipment operating in the frequency bands of 118 through 136 MHz and 225 through 400 MHz and having power outputs of up to 100 watts and located within 6 feet of the equipment furnished under this specification, assuming such equipment meets applicable FCC requirements for stray and spurious radiation.

__1-3.3.13 Adjustments.-__ The VOR/DME equipment shall be designed such that all transmitter, transponder, monitor and control adjustments essential for proper operation and maintenance (other than tuning of RF stages or where otherwise indicated herein) and all indications resulting therefrom shall be accessible locally via the FCPU to PMDT interface (3-3.3.1.2.2) and remotely from the MPS in accordance with paragraph 1-3.3.13.3 herein.

__1-3.3.13.1 Adjustment display.-__ A PMDT in local mode of operation connected to the FCPU terminal interface shall be capable of displaying all control settings on a neatly formatted screen or screens. The parameter and its current value must be clearly shown. For purposes of making adjustments, parameters must be selectable by cursor, menu, or by typing in a name or code. For a system which requires operator input to make adjustments, on-screen help must be provided. The ability to increase or decrease a parameter setting in minimum steps consistent with individual parameter tolerances must be provided together with the ability to directly enter a parameter setting from the portable terminal keyboard.

1-3.3.13.2 Adjustment storage.- Electronically entered control settings must be stored in non-volatile memory either immediately upon entry or at the conclusion of an adjustment/maintenance operation. Storing of control settings shall be automatic and shall provide notification to the operator. It shall not be possible for equipment to be restored to normal operation without saving control settings. For this specification, non-volatile storage is considered to be at least 90 days.

1-3.3.13.3 Remote communications.- Remote communications shall be established by the use of Government furnished dedicated 4-wire telephone lines between the VOR/DME facility and the RSCE location and thence to the MPS via the RSCE to MPS interface (see paragraph 9-3.2.2.1). The telephone lines shall be private line, data voice-grade circuits that will be unity gain and will be furnished with 0dB transmission level point (TLP) at the send and receive interface.

The capability for remote communications shall be such that any function which can be performed locally through the FCPU to PMDT interface with the PMDT in local mode, can also be performed remotely.

1-3.3.14 Frequency sources.- Each VOR equipment required to provide an RF output on an assigned frequency shall employ a crystal controlled frequency source whereby the required carrier frequency is derived from a single frequency determining component. A crystal oscillator where used (installed) in the VOR and a spare shall be provided. In lieu of a set of crystals, VOR frequency may be controlled by a crystal referenced frequency synthesizer adjustable over the full frequency range of 108.0 MHz to 118.0 MHz in steps of .05 MHz. The DME shall employ a frequency synthesizer whereby any required frequency (see Table 1) is derived from a single frequency determining component. Means shall be provided to prevent radiation of an RF output signal on other than the desired channel frequency due to malfunction of the frequency synthesizer circuits. Selection of the assigned DME channel and mode (x or y) shall be accomplished through the FCPU and shall display the DME channel and mode selected. Each unit of equipment shall be tuned and adjusted for operation on a channel (operating frequency) assigned by the Government. The contractor shall request the frequency assignment at least 120 days before shipping instructions are requested.

1-3.3.14.1 Frequency stability.- Radio frequency determining components shall be of sufficient tolerance and stability to provide output frequencies which are within ±.001% (DME) and ±0.0005% (VOR) of the assigned channel frequency (see Table 1). The VOR tolerance is for initial (room temperature) conditions, with ±.001% tolerance allowed over the service conditions.

1-3.3.14.2 Spectrum requirements.- The equipment shall meet the requirements of the Manual of Regulations and Procedures for Federal Radio Frequency Management, National Telecommunications and Information Administration (NTIA) Manual for aeronautical radio navigation station.

1-3.3.14.3 Electromagnetic interference control.- The VOR/DME equipment shall be designed to meet the electromagnetic compatibility requirements of paragraphs 3.3.8 through 3.3.8.2 of Specification FAA-G-2100. The contractor shall obtain Federal Communications Commission (FCC) type acceptance in accordance with FCC Rules and Regulations, Part 2. For equipment designed for interface and connection to either the public or private telephone networks, the contractor shall obtain FCC Registration in accordance with FCC Rules and Regulations, Part 68. The FCPU and any other microprocessors shall meet the requirements for Class B computing devices in accordance with Subpart J, Part 15, of the FCC Rules and Regulations.

1-3.3.15 Environmental service conditions.- For the VOR/DME equipment housed inside the shelter, ambient conditions shall be those of Environment II of Table III of FAA-G-2100 except that the lower temperature shall be -40° C in lieu of 10° C. For equipment not housed in the shelter (e.g., VOR monitor antennas), the ambient conditions shall be those of Environment III of Table III of FAA-G-2100. The RSCE shall be designed for the ambient conditions of Environment I of Table III of FAA-G-2100.

1-3.3.16 Primary power.- The VOR/DME facility primary power is supplied from a nominal 120/240 volt, 60 Hz, three wire, single phase AC power source. The AC power shall be utilized for operation of the BCPS and for cabinet convenience outlets Only. Except as allowed in Part 2 of this specification, all other equipment at the facility shall operate from the DC output of the BCPS or, in the event of failure of the AC supply, from the output of the battery bank (Government furnished). The RSCE shall be designed to operate from a nominal 120 volt, 60 Hz, three wire, single phase AC power source.

1-3.3.17 Transient suppression.- Equipment shall be protected against damage or operational upset due to lightning surges on the incoming AC power line(s) or the communication lines. For design and test purposes, the equipment contractor may assume that the facility is provided with AC surge arresters installed across each line to neutral at the facility main service disconnect box which limit the transient voltage waveform appearing at the BCPS input to 1,500 volts with a rise time of 10 microseconds and a decay time to one-half amplitude of 20 microseconds. (See also Figure II of Specification FAA-G-2100.)

<u>1-3.3.17.1 Static discharge.-</u> The equipment shall be protected from the harmful effects of electrostatic discharge in accordance with DOD-STD-1686.

<u>1-3.3.18 stabilization of performance characteristics and monitor response time.-</u> Within 6 seconds after reapplication of primary power to the input of the BCPS, and in the absence of the battery bank, the power output of each transmitter/transponder shall have reached a level of not less than 90% of the steady state level for the same set of service conditions and all other performance characteristics shall be within their prescribed tolerances. Concurrently each monitor shall have sensed correct operation and provided the appropriate (no fault and non-alarm) output indications.

<u>1-3.3.19 VOR and DME auto-reset function.-</u> The VOR and DME monitors and/or the FCPU shall include firmware which will automatically reset the system(s) and continue normal operation if there are no more than three alarms within any 15 minute period. If a fourth alarm occurs during any 15 minute period, no further auto-resets would be attempted. Automatic reset shall not be initiated for alarms generated by the VOR 16-point executive monitor function (paragraph 5-3.3.6.1 herein).

The initial reset shall occur 20 ±2 seconds after the first alarm condition. If the system (VOR or DME) remains happy (1-3.1.10.7) for 15 minutes ±2 seconds after the reset occurs, the auto-reset function shall be restored to its full enable state.

If the system does not reset to normal or if another alarm (second) occurs prior to the end of the initial 15 minute period, another attempt at reset shall be initiated 32 ±3 seconds after the initial reset attempt or after the new alarm. If the reset is successful and the system remains happy for 15 minutes ±2 seconds after the reset occurs, the auto-reset function shall be restored to its full enable state.

If the system does not reset to normal or if another alarm (third) occurs prior to the end of the initial 15 minute period, another attempt at reset shall be initiated 70 ±5 seconds after the last reset attempt or the new alarm. If the reset is successful and the system remains happy for 15 minutes ±2 seconds after the reset occurs, the auto-reset function shall be restored to its full enable state.

If the system does not reset to normal or if another alarm (fourth) occurs prior to the end of the initial 15 minute period, no further auto-resets shall be attempted and operator intervention shall be required to restore the system to normal and to return the auto-reset function to its full enable state. Notification of all alarm conditions and reset attempts shall be provided to the MPS.

Override timing and counter circuitry shall be provided to ensure that regardless of the status of the auto-reset function, the system shall not restore to normal if there are more than three alarms in any 15 minute period.

1-3.4 Reliability of electronic equipment.- The VOR/DME equipment to be furnished under this specification shall, through demonstration or calculations, exhibit the reliability figures specified below. For those systems utilizing redundancy, reliability shall be determined on the basis of periodic maintenance at intervals of 2190 hours (three month intervals). Reliability predictions shall be in accordance with Military Standard 756 and Military Handbook 217.

1-3.4.1 VOR mean time between failure (MTBF).- The VOW system (Units 1 through 4 of paragraph 1-3.2) shall have a calculated MTBF of not less than 7500 hours. (See paragraph 1-3.1.21).

1-3.4.2 DME MTBF.- The DME system (Units 6 and 7 of paragraph 1-3.2.1) shall have a calculated MTBF of not less than 5000 hours.

1-3.4.3 Remote status and communications equipment (RSCE).- The RSCE shall have a calculated MTBF of not less than 20,000 hours. This model does not include terminals, modems, telephone lines, or any oter interface circuitry.

1-3.5 Maintainability of electronic equipment.- The VOR/DME equipment to be furnished under this specification shall comply with the maintainability requirements specified below. The figures specified shall apply to a complete VOR/DME system including the RSCE (see paragraph 1-3.2.1 herein).

1-3.5.1 Maintenance concept.- The VOR/DME system will utilize a two level concept of maintenance, site and depot. This concept assumes the use of modular designed equipment which enables field technicians to correct a majority of equipment failures on-site by replacing the faulty module. The VOR/DME system will utilize this concept of maintenance throughout its operational life cycle.

after the reset occurs, the auto-reset function shall be restored to its full enable state.

If the system does not reset to normal or if another alarm (fourth) occurs prior to the end of the initial 15 minute period, no further auto-resets shall be attempted and operator intervention shall be required to restore the system to normal and to return the auto-reset function to its full enable state. Notification of all alarm conditions and reset attempts shall be provided to the MPS.

Override timing and counter circuitry shall be provided to ensure that regardless of the status of the auto-reset function, the system shall not restore to normal if there are more than three alarms in any 15 minute period.

<u>1-3.4 Reliability of electronic equipment</u>.- The VOR/DME equipment to be furnished under this specification shall, through demonstration or calculations, exhibit the reliability figures specified below. For those systems utilizing redundancy, reliability shall be determined on the basis of periodic maintenance at intervals of 2190 hours (three month intervals). Reliability predictions shall be in accordance with Military Standard 756 and Military Handbook 217.

<u>1-3.4.1 VOR mean time between failure (MTBF)</u>.- The VOW system (Units 1 through 4 of paragraph 1-3.2) shall have a calculated MTBF of not less than 7500 hours. (See paragraph 1-3.1.2).

<u>1-3.4.2 DME MTBF</u>.- The DME system (Units 6 and 7 of paragraph 1-3.2.1) shall have a calculated MTBF of not less than 5000 hours.

<u>1-3.4.3 Remote status and communications equipment (RSCE)</u>.- The RSCE shall have a calculated MTBF of not less than 20,000 hours. This model does not include terminals, modems, telephone lines, or any oter interface circuitry.

<u>1-3.5 Maintainability of electronic equipment</u>.- The VOR/DME equipment to be furnished under this specification shall comply with the maintainability requirements specified below. The figures specified shall apply to a complete VOR/DME system including the RSCE (see paragraph 1-3.2.1 herein).

<u>1-3.5.1 Maintenance concept</u>.- The VOR/DME system will utilize a two level concept of maintenance, site and depot. This concept assumes the use of modular designed equipment which enables field technicians to correct a majority of equipment failures on-site by replacing the faulty module. The VOR/DME system will utilize this concept of maintenance throughout its operational life cycle.

2-3.8 Software.- All VOR/DME software shall be developed and documented in accordance with DOD-STD-2167. "Programs" written at levels that do not require assembly or cross-assembly can be adequately documented with logic diagrams and/or truth tables. The documentation specified in DOD-STD-2167 is not required to adequately support this low level of progr.... All forma; software reviews and audits, including Reliability and Maintainability tests/audits, shall be conducted in accordance with MIL-STD-1521. A subset of the data item descriptions (DIDs) contained in DOD-STD-2167 will be specified in the contract and shall be delivered by the contractor. The contractor shall include the software design/development effort in the Configuration Management plan for the progzam and insure that the software meets CM requirements of DOD-STD-2167.

1-3.9 Documentation.- Level 3 engineering drawings shall be prepared in accordance with DOD-D-1000 and DOD-STD-100. Course materials shall be developed in accordance with FAA-STD-028. Parts lists in hard copy used for provisioning shall be formatted in accordance with FAA-G-1375 for spare parts-peculiar and MIL-STD-1561 for all other lists. Parts list for provisioning developed from LSA shall be formatted in accordance with MIL-STD-1388-2A and documented in an automated medium compatible with the FAA LSA automated database. Technical instruction books in accordance with Specification FAA-D-2494 shall be provided as specified in the contract schedule.

1-3.10 Logistics.- Logistics support for the VOR/DME equipment shall be in accordance with MIL-STD-1388-1A and MIL-STD-1388-2A.

1-3.10.1 Supply Support.- Spare parts-peculiar shall be indentified and acquired in accordance with FAA Specification FAA-G-1375. Repairable LRUs will be identified and spares requirements quantified from data generated by logistic support analysis (LSA) in accordance with MIL-STD-1388-1A. Provisioning lists will be developed from data generated by LSA and formatted in accordance with MIL-STD-1388-2A. Provisioning will be accomplished in accordance with MIL-STD-1561.

1-3.11 Training.- The contractor shall submit a training prOpOsal for the VOR/DME equipment in accordance with the requirements of FAA-STD-028 and as further delineated in the contract schedule.

1-4 QUALITY ASSURANCE PROVISIONS

1-4.1 General.- The contractor shall establish and maintain a quality control program as specified in the contract schedule. The quality assurance provisions of Section 4 of Specification FAA-G-2100 shall also apply.

1-4.1.2 Set/unit testing.- Each unit of equipment furnished under this specification shall be tested when incorporated as a complete set, including design qualification and type tests under environmental conditions of paragraph 4.11 of FAA-G-2100, "Quality Assurance Provisions". Where demonstration of compliance with specific performance requirements of individual units is not practicable when connected and operated as a set, supplemental tests (design qualification, type, and production) shall be conducted on the individual units prior to their assembly into a set.

1-4.1.3 Requirements to be tested.- All requirements defined in the specification must be verified in the test procedures. These requirements are listed in the Verification Requirements Traceability Matrix (VRTM) contained in the Part 1, Table 2, herein. Another VRTM for the software, independent of the hardware (consistent with the requirements of DOD-STD-2167, NAS-MD-790 and this specification), shall be developed by the contractor.

1-4.1.4 Master Test Plan.- The contractor shall furnish a Master Test Plan (MTP) in accordance with FAA-STD-024 to the Government for review and approval. The MTP and its associated test plans shall be a coherent and comprehensive demonstration that all specification requirements contained in the VRTM are satisfied.

1-4.1.5 VRTM definitions.- The following definitions are provided to clarify terms in the VRTM. This information is to be used by the contractor for preparation of test and evaluation procedures defined in paragraphs 1-4.1.2 through 1-4.1.4.

1-4.1.5.1 Verification Methods.-

(a) Test - Test is a method of verifying performance requirements of subsystem/system or configuration items by quantitative measurement of controlled functional or environmental stimuli. These dynamic measurements are made using standardized laboratory equipment, procedures or other services, then analyzed to determine their compliance.

(b) Demonstration - Demonstration is a method of verifying subsystem/system or configuration item requirements by observing their functional response to dynamic exercising. This qualitative evaluation is made using criteria from technical procedure, excluding measurements. Acceptance is based on pass/fail results.

(c) Inspection - Inspection is a method of verifying acceptability of hardware, software or technical documentation by determining the compliance to requirements by visual examination of condition or content. The criteria for examination is obtained from standards, schematics or affidavits consisting of static-state measurements, inventories or conformance features. The success criteria is pass/fail.

(d) Analysis - Analysis is a method of verifying requirements for hardware or software design by comparing it mathematically (modeling) or otherwise with known scientific and technical principles, procedures or practices. Results of the comparison are used to estimate the capability or' the design to meet system and mission requirements. Justification for analysis includes impractical or impossible access to measurements, determining statistical probabilities and percentiles.

1-4.1.5.2 Test requirements in the VRTM.- Indication of verification methods in the VRTM shall be used by the contractor in developing test procedures. Notes are provided which further define the testing requirements in the VRTM.

1-4.1.6 Testing Documents.- Testing and documentation shall be performed in accordance with the quality assurance provisions of FAA-G-2100.

1-4.1.7 Installation and stand alone software.- The contractor shall provide all software and procedures required for testing the VOR/DME subsystems and the interface between subsystems during installation at each operational site and that which shall also be required to provide system operation and control when normal RMS operation is not possible.

1-4.2 Fail-safe testing.- The contractor shall develop a test plan to demonstrate that the FCPU and the VOR and DME monitors will meet the specified fail-safe requirements of paragraphs 3-3.5, 5-3.3.8.9.1 and 7-3.3.4, respectively. The demonstration test plan shall be submitted to the Government for approval as part of the Master Test Plan (paragraph 1-4.1.4) and as specified in the contract schedule.

1-4.3 Preventive maintenance verification.- The contractor shall verify that the equipment meets the preventive maintenance requirements of paragraph 1-3.5.2 by providing an analysis Of the maintenance procedures that are to be included in the technical instruction book. The analysis shall be included in the Master Test Plan (paragraph 1-4.1.4) to be submitted to the Government for approval in accordance with the contract schedule.

1-5 PREPARATION FOR DELIVERY

documentation by determining the compliance to requirements by visual examination of condition or content. The criteria for examination is obtained from standards, schematics or affidavits consisting of static-state measurements, inventories or conformance features. The success criteria is pass/fail.

(d) Analysis - Analysis is a method of verifying requirements for hardware or software design by comparing it mathematically (modeling) or otherwise with known scientific and technical principles, procedures or practices. Results of the comparison are used to estimate the capability or' the design to meet system and mission requirements. Justification for analysis includes impractical or impossible access to measurements, determining statistical probabilities and percentiles.

1-4.1.5.2 Test requirements in the VRTM.- Indication of verification methods in the VRTM shall be used by the contractor in developing test procedures. Notes are provided which further define the testing requirements in the VRTM.

1-4.1.6 Testing Documents.- Testing and documentation shall be performed in accordance with the quality assurance provisions of FAA-G-2100.

1-4.1.7 Installation and stand alone software.- The contractor shall provide all software and procedures required for testing the VOR/DME subsystems and the interface between subsystems during installation at each operational site and that which shall also be required to provide system operation and control when normal RMS operation is not possible.

1-4.2 Fail-safe testing.- The contractor shall develop a test plan to demonstrate that the FCPU and the VOR and DME monitors will meet the specified fail-safe requirements of paragraphs 3-3.5, 5-3.3.8.9.1 and 7-3.3.4, respectively. The demonstration test plan shall be submitted to the Government for approval as part of the Master Test Plan (paragraph 1-4.1.4) and as specified in the contract schedule.

1-4.3 Preventive maintenance verification.- The contractor shall verify that the equipment meets the preventive maintenance requirements of paragraph 1-3.5.2 by providing an analysis Of the maintenance procedures that are to be included in the technical instruction book. The analysis shall be included in the Master Test Plan (paragraph 1-4.1.4) to be submitted to the Government for approval in accordance with the contract schedule.

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TABLE 1

VOR-TACAN-DME CHANNEL FREQUENCIES AND PAIRING

VHF Chan. Freq. MHZ	Chan. No.	DME-TACAN Inter. Freq. MHz	Reply Freq. MHz	VHF Chan. Freq. MHz	Chan. No	DME-TACAN Inter. Freq. MHz	Reply Freq. MHZ
-	1X	1025	962	108.20 VOR	19X	1043	980
-	1Y	1025	1088	108.25 VOR	19Y	1043	1106
-	2X	1026	963	108.30 ILS	20X	1044	981
-	2Y	1026	1089	108.35 ILS	20Y	1044	1107
-	3X	1027	964	108.40 VOR	21X	1045	982
-	3Y	1027	1090	108.45 VOR	21Y	1045	1108
-	4X	1028	965	108.50 ILS	22X	1046	983
-	4Y	1028	1091	108.55 ILS	22Y	1046	1109
-	5X	1029	966	108.60 VOR	23X	1047	984
-	5Y	1029	1092	108.65 VOR	23Y	1047	1110
-	6X	1030	967	108.70 ILS	24X	1048	985
-	6Y	1030	1093	108.75 ILS	24Y	1048	1111
-	7X	1031	968	108.80 VOR	25X	1049	986
-	7Y	1031	1094	108.85 VOR	25Y	1049	1112
-	8X	1032	969	108.90 ILS	26X	1050	987
-	8Y	1032	1095	108.95 ILS	26Y	1050	1113
-	9X	1033	970	109.00 VOR	27X	1051	988
-	9Y	1033	1096	109.05 VOR	27Y	1051	1114
-	10X	1034	971	109.10 ILS	28X	1052	989
-	10Y	1034	1097	109.15 ILS	28Y	1052	1115
-	11X	1035	972	109.20 VOR	29X	1053	990
-	11Y	1035	1098	109.25 VOR	29Y	1053	1116
-	12X	1036	973	109.30 ILS	30X	1054	991
-	12Y	1036	1099	109.35 ILS	30Y	1054	1117
-	13X	1037	974	109.40 VOR	31X	1055	992
-	13Y	1037	1100	109.45 VOR	31Y	1055	1118
-	14X	1038	975	109.50 ILS	32X	1056	993
-	14Y	1038	1101	109.55 ILS	32Y	1056	1119
-	15X	1039	976	109.60 VOR	33X	1057	994
-	15Y	1039	1102	109.65 VOR	33Y	1057	1120
-	16X	1040	977	109.70 ILS	34X	1058	995
-	16Y	1040	1103	109.75 ILS	34Y	1058	1121
108.00*	17X	1041	978	109.80 VOR	35X	1059	996
108.05 VOR	17Y	1041	1104	109.85 VOR	35Y	1059	1122
108.10 ILS	18X	1042	979	109.90 ILS	36X	1060	997
108.15 ILS	18Y	1042	1105	109.95 ILS	36Y	1060	1123

*108.00 MHz is not scheduled for facilities. The frequencies of channel 17X are assigned to facilities for testing airborne system components.

TABLE 1 (continued)

VOR-TACAN-DME CHANNEL FREQUENCIES AND PAIRING

VHF Chan. Freq. MHz		Chan. No.	DME-TACAN Inter. Freq. MHz	DME-TACAN Reply Freq. MHz	VHF Chan. Freq. MHz		Chan. No.	DME-TACAN Inter. Freq. MHz	DME-TACAN Reply Freq. MHz
110.00	VOR	37X	1061	998	111.90	ILS	56X	1080	1017
110.05	VOR	37Y	1061	1124	111.95	ILS	56Y	1080	1143
110.10	ILS	38X	1062	999	112.00	VOR	57X	1081	1018
110.15	ILS	38Y	1062	1125	112.05	VOR	57Y	1081	1144
110.20	VOR	39X	1063	1000	112.10	VOR	58X	1082	1019
110.25	VOR	39Y	1063	1126	112.15	VOR	58Y	1082	1145
110.30	ILS	40X	1064	1001	112.20	VOR	59X	1083	1020
110.35	ILS	40Y	1064	1127	112.25	VOR	59Y	1083	1146
100.40	VOR	41X	1065	1002			60X	1084	1021
110.45	VOR	41Y	1065	1128	-		60Y	1084	1147
110.50	ILS	42X	1066	1003	-		61X	1085	1022
110.55	ILS	42Y	1066	1129	-		61Y	1085	1148
110.60	VOR	43X	1067	1004	-		62X	1086	1023
110.65	VOR	43Y	1067	1130	-		62Y	1086	1149
110.70	ILS	44X	1068	1005	-		63X	1087	1024
110.75	ILS	44Y	1068	1131	-		63Y	1087	1150
110.80	VOR	45X	1069	1006	-		64X	1088	1151
110.85	VOR	45Y	1069	1132	-		64Y	1088	1025
110.90	ILS	46X	1070	1007	-		65X	1089	1152
110.95	ILS	46Y	1070	1133	-		65Y	1089	1026
111.00	VOR	47X	1071	1008	-		66X	1090	1153
111.05	VOR	47Y	1071	1134	-		66Y	1090	1027
111.10	ILS	48X	1072	1009	-		67X	1091	1154
111.15	ILS	48Y	1072	1135	-		67Y	1091	1028
111.20	VOR	49X	1073	1010	-		68X	1092	1155
111.25	VOR	49Y	1073	1136	-		68Y	1092	1029
111.30	ILS	50X	1074	1011	-		69X	1093	1156
111.35	ILS	50Y	1074	1137			69Y	1093	1030
111.40	VOR	51X	1075	1012	113.30	VOR	70X	1094	1157
111.45	VOR	51Y	1075	1138	112.35	VOR	70Y	1094	1031
111.50	ILS	52X	1076	1013	112.40	VOR	71X	1095	1158
111.55	ILS	52Y	1076	1139	112.45	VOR	71Y	1095	1032
111.60	VOR	53X	1077	1014	112.50	VOR	72X	1096	1159
111.65	VOR	53Y	1077	1140	112.55	VOR	72Y	1096	1033
111.70	ILS	54X	1078	1015	112.60	VOR	73X	1097	1160
111.75	ILS	54Y	1078	1141	112.65	VOR	73Y	1097	1034
111.80	VOR	55X	1079	1016	112.70	VOR	74X	1098	1161
111.85	VOR	55Y	1079	1142	112.75	VOR	74Y	1098	1035

TABLE 1 (continued)

VOR-TACAN-DME CHANNEL FREQUENCIES AND PAIRING

VHF Chan. Freq. MHz		Chan. No.	DME-TACAN Inter. Freq. MHz	DME-TACAN Reply Freq. MHz	VHF Chan. Freq. MHz		Chan. No.	DME-TACAN Inter. Freq. MHz	DME-TACAN Reply Freq. MHz
110.00	VOR	37X	1061	998	111.90	ILS	56X	1080	1017
110.05	VOR	37Y	1061	1124	111.95	ILS	56Y	1080	1143
110.10	ILS	38X	1062	999	112.00	VOR	57X	1081	1018
110.15	ILS	38Y	1062	1125	112.05	VOR	57Y	1081	1144
110.20	VOR	39X	1063	1000	112.10	VOR	58X	1082	1019
110.25	VOR	39Y	1063	1126	112.15	VOR	58Y	1082	1145
110.30	ILS	40X	1064	1001	112.20	VOR	59X	1083	1020
110.35	ILS	40Y	1064	1127	112.25	VOR	59Y	1083	1146
100.40	VOR	41X	1065	1002			60X	1084	1021
110.45	VOR	41Y	1065	1128	-		60Y	1084	1147
110.50	ILS	42X	1066	1003	-		61X	1085	1022
110.55	ILS	42Y	1066	1129	-		61Y	1085	1148
110.60	VOR	43X	1067	1004	-		62X	1086	1023
110.65	VOR	43Y	1067	1130	-		62Y	1086	1149
110.70	ILS	44X	1068	1005	-		63X	1087	1024
110.75	ILS	44Y	1068	1131	-		63Y	1087	1150
110.80	VOR	45X	1069	1006	-		64X	1088	1151
110.85	VOR	45Y	1069	1132	-		64Y	1088	1025
110.90	ILS	46X	1070	1007	-		65X	1089	1152
110.95	ILS	46Y	1070	1133	-		65Y	1089	1026
111.00	VOR	47X	1071	1008	-		66X	1090	1153
111.05	VOR	47Y	1071	1134	-		66Y	1090	1027
111.10	ILS	48X	1072	1009	-		67X	1091	1154
111.15	ILS	48Y	1072	1135	-		67Y	1091	1028
111.20	VOR	49X	1073	1010	-		68X	1092	1155
111.25	VOR	49Y	1073	1136	-		68Y	1092	1029
111.30	ILS	50X	1074	1011	-		69X	1093	1156
111.35	ILS	50Y	1074	1137			69Y	1093	1030
111.40	VOR	51X	1075	1012	113.30	VOR	70X	1094	1157
111.45	VOR	51Y	1075	1138	112.35	VOR	70Y	1094	1031
111.50	ILS	52X	1076	1013	112.40	VOR	71X	1095	1158
111.55	ILS	52Y	1076	1139	112.45	VOR	71Y	1095	1032
111.60	VOR	53X	1077	1014	112.50	VOR	72X	1096	1159
111.65	VOR	53Y	1077	1140	112.55	VOR	72Y	1096	1033
111.70	ILS	54X	1078	1015	112.60	VOR	73X	1097	1160
111.75	ILS	54Y	1078	1141	112.65	VOR	73Y	1097	1034
111.80	VOR	55X	1079	1016	112.70	VOR	74X	1098	1161
111.85	VOR	55Y	1079	1142	112.75	VOR	74Y	1098	1035

TABLE 1 (continued)

VOR-TACAN-DME CHANNEL FREQUENCIES AND PAIRING

VHF Chan. Freq. MHz		Chan. No.	DME-TACAN Inter. Freq. MHz	Reply Freq. MHz
116.60	VOR	113X	1137	1200
116.65	VOR	113Y	1137	1074
116.70	VOR	114X	1138	1201
116.75	VOR	114Y	1138	1075
116.80	VOR	115X	1139	1202
116.85	VOR	115Y	1139	1076
116.90	VOR	116X	1140	1203
116.95	VOR	116Y	1140	1077
117.00	VOR	117X	1141	1204
117.05	VOR	117Y	1141	1078
117.10	VOR	118X	1142	1205
117.15	VOR	118Y	1142	1079
117.20	VOR	119X	1143	1206
117.25	VOR	119Y	1143	1080
117.30	VOR	120X	1144	1207
117.35	VOR	120Y	1144	1081
117.40	VOR	121X	1145	1208
117.45	VOR	121Y	1145	1082
117.50	VOR	122X	1146	1209
117.55	VOR	122Y	1146	1083
117.60	VOR	123X	1147	1210
117.65	VOR	123Y	1147	1084
117.70	VOR	124X	1148	1211
117.75	VOR	124Y	1148	1085
117.80	VOR	125X	1149	1212
117.85	VOR	125Y	1149	1086
117.90	VOR	126X	1150	1213
117.95	VOR	126Y	1150	1087

TABLE 1 (continued)

VOR-TACAN-DME CHANNEL FREQUENCIES AND PAIRING

VHF Chan. Freq. MHz		Chan. No.	DME-TACAN Inter. Freq. MHz	Reply Freq. MHz
116.60	VOR	113X	1137	1200
116.65	VOR	113Y	1137	1074
116.70	VOR	114X	1138	1201
116.75	VOR	114Y	1138	1075
116.80	VOR	115X	1139	1202
116.85	VOR	115Y	1139	1076
116.90	VOR	116X	1140	1203
116.95	VOR	116Y	1140	1077
117.00	VOR	117X	1141	1204
117.05	VOR	117Y	1141	1078
117.10	VOR	118X	1142	1205
117.15	VOR	118Y	1142	1079
117.20	VOR	119X	1143	1206
117.25	VOR	119Y	1143	1080
117.30	VOR	120X	1144	1207
117.35	VOR	120Y	1144	1081
117.40	VOR	121X	1145	1208
117.45	VOR	121Y	1145	1082
117.50	VOR	122X	1146	1209
117.55	VOR	122Y	1146	1083
117.60	VOR	123X	1147	1210
117.65	VOR	123Y	1147	1084
117.70	VOR	124X	1148	1211
117.75	VOR	124Y	1148	1085
117.80	VOR	125X	1149	1212
117.85	VOR	125Y	1149	1086
117.90	VOR	126X	1150	1213
117.95	VOR	126Y	1150	1087

TABLE 2
VOR/DME SYSTEM-VERIFICATION REQUIREMENT TRACEABILITY MATRIX

REQUIREMENTS		TEST LEVEL AND METHOD					TEST LOCATION		REMARKS
PARAGRAPH NUMBER	TITLE	FIRST ARTICLE DESIGN QUALIFICATION	TYPE TEST NORMAL CONDITIONS	TYPE TEST SERVICE CONDITIONS	PRODUCTION TESTS	OPERATIONAL SHAKEDOWN	FACTORY	ASM-150/ ACT	
1-3.3.13.2	Adjustment storage	D					X		
1-3.3.13.3	Remote communications	A,T					X		
1-1-3.3.14	Frequency sources	D					X		
1-3.3.14.1	Frequency stability	T	T	T			X		
1-3.3.14.2	Spectrum requirements	T	T				X		
1-3.3.14.3	Electromagnetic interference control	I,T					X		
1-3.3.17	Transient protection	T					X		
1-3.3.17.1	Static discharge	T					X		
1-3.3.18	Stabilization of perf. chars. and Mon. Res Time	D					X		
1-3.3.19	VOR and DME auto-reset function	T					X		
1-3.4	Reliability of electronic equipment	A,D					X		
1-3.4.1	VOR MTBF	A					X		
1-3.4.2	DME MTBF	A					X		
1-3.4.3	RSCE MTBF	A					X		
1-3.5.2	Preventive maintenance time	A					X		
1-3.5.3	Corrective maintenance time	A					X		
2-3.3.5	DC output voltage	I					X		
2-3.3.5.1	48 volt supply		T				X		
2-3.3.6	Output capacity			T	T		X	X	
2-3.3.6.1	Battery capacity	A,T			T		X	X	
2-3.3.7	Effect of presence of battery bank		T						
2-3.3.8	Isolation protection	D,T							
3-3.3.1.1	VOR/DME RMS functions	D			D		X		

VERIFICATION METHOD: INSPECTION-I, ANALYSIS-A, TEST-T, DEMONSTRATION-D

TABLE 2

VOR/DME SYSTEM-VERIFICATION REQUIREMENT TRACEABILITY MATRIX

REQUIREMENTS		TEST LEVEL AND METHOD					TEST LOCATION		REMARKS
PARAGRAPH NUMBER	TITLE	FIRST ARTICLE DESIGN QUALIFICATION	TYPE TEST NORMAL CONDITIONS	TYPE TEST SERVICE CONDITIONS	PRODUCTION TESTS	OPERATIONAL SHAKEDOWN	FACTORY	ASM-150/ ACT	
3-3.3.1.2.1	FCPU to RSCE interface	I					X		
3-3.3.1.2.2	PMDT interface	I					X		
3-3.3.1.3	PMDT interface commands	T				T	X	X	
3-3.3.1.4	Protocol, voice/data interface	A,T					X		
3-3.3.1.5	Memory	A					X		
3-3.3.1.6	Volatility	A					X		
3-3.3.1.7	Alarm and message format	D					X		
3-3.3.1.7.1	Alarms	T		T	T		X	X	
3-3.3.1.7.2	Maintenance alerts	T		T	T		X	X	
3-3.3.1.8	VOR/DME RMS sampling frequency	T					X		
3-3.3.1.9	Realtime clock	A,T					X		
3-3.3.1.10	Trend analysis	D					X		
3-3.3.1.11	VOR/DME RMS security	D					X		
3-3.3.1.12	Data communications failures	D					X		
3-3.3.2.1	VOR/DME equipment adjustment	D					X		
3-3.3.2.2	VOR/DME equipment testing	D				D	X	X	
3-3.3.2.3.1.1	FM subcarrier frequency	T	T			D	X	X	
3-3.3.2.3.1.2	30 Hz FM signal	T	T				X		
3-3.3.2.3.1.3	Harmonic distortion	T	T				X		
3-3.3.2.3.2.1	FM output level adjustment	T	T				X		
3-3.3.2.3.2.2	FM output level stability	T	T				X		
3-3.3.2.3.2.3	Hum distortion	T	T				X		
3-3.3.2.3.3.1	30 Hz AM signal phase	T	T				X		

VERIFICATION METHOD: INSPECTION-I, ANALYSIS-A, TEST-T, DEMONSTRATION-D

TABLE 2

VOR/DME SYSTEM-VERIFICATION REQUIREMENT TRACEABILITY MATRIX

REQUIREMENTS		TEST LEVEL AND METHOD					TEST LOCATION		REMARKS
PARAGRAPH NUMBER	TITLE	FIRST ARTICLE DESIGN QUALIFICATION	TYPE TEST NORMAL CONDITIONS	TYPE TEST SERVICE CONDITIONS	PRODUCTION TESTS	OPERATIONAL SHAKEDOWN	FACTORY	ASM-150/ ACT	
3-3.3.1.2.1	FCPU to RSCE interface	I					X		
3-3.3.1.2.2	PMDT interface	I					X		
3-3.3.1.3	PMDT interface commands	T				T	X	X	
3-3.3.1.4	Protocol, voice/data interface	A,T					X		
3-3.3.1.5	Memory	A					X		
3-3.3.1.6	Volatility	A					X		
3-3.3.1.7	Alarm and message format	D					X		
3-3.3.1.7.1	Alarms	T		T	T		X	X	
3-3.3.1.7.2	Maintenance alerts	T		T	T		X	X	
3-3.3.1.8	VOR/DME RMS sampling frequency	T					X		
3-3.3.1.9	Realtime clock	A,T					X		
3-3.3.1.10	Trend analysis	D					X		
3-3.3.1.11	VOR/DME RMS security	D					X		
3-3.3.1.12	Data communications failures	D					X		
3-3.3.2.1	VOR/DME equipment adjustment	D					X		
3-3.3.2.2	VOR/DME equipment testing	D				D	X	X	
3-3.3.2.3.1.1	FM subcarrier frequency	T	T			D	X	X	
3-3.3.2.3.1.2	30 Hz FM signal	T	T				X		
3-3.3.2.3.1.3	Harmonic distortion	T	T				X		
3-3.3.2.3.2.1	FM output level adjustment	T	T				X		
3-3.3.2.3.2.2	FM output level stability	T	T				X		
3-3.3.2.3.2.3	Hum distortion	T	T				X		
3-3.3.2.3.3.1	30 Hz AM signal phase	T	T				X		

VERIFICATION METHOD: INSPECTION-I, ANALYSIS-A, TEST-T, DEMONSTRATION-D

TABLE 2

VOR/DME SYSTEM-VERIFICATION REQUIREMENT TRACEABILITY MATRIX

REQUIREMENTS		TEST LEVEL AND METHOD					TEST LOCATION		REMARKS
PARAGRAPH NUMBER	TITLE	FIRST ARTICLE DESIGN QUALIFICATION	TYPE TEST NORMAL CONDITIONS	TYPE TEST SERVICE CONDITIONS	PRODUCTION TESTS	OPERATIONAL SHAKEDOWN	FACTORY	ASM-150/ ACT	
3-3.3.3.1.1	Data transmission	D					X		
3-3.3.3.2	Input transformer	I					X		
3-3.3.4	Voice identification	T					X		
3-3.3.4.1	Voice recording function	D					X		
3-3.3.4.2	Erase function	D					X		
3-3.3.4.3	Frequency response	T			T		X		
3-3.3.4.4	Signal to noise ratio	T					X		
3-3.3.4.6	Output level	T					X		
3-3.3.4.7	Nonvolatility	A					X		
3-3.3.4.8	Alternate voice input	A,D,T					X		
3-3.5	FCPU fail-safe requirements	T			T		X		DQT-3 FREQ
4-3.3.3.1	Carrier power output	T		T			X		DQT-3 FREQ
4-3.3.3.1.1	Carrier power output level stability and control	T		T			X		DQT-3 FREQ
4-3.3.3.1.2	Stabilization of performance characteristics	T					X		
4-3.3.3.2	Output signal spectrum	T			T		X		
4-3.3.3.3	AM with 9960 Hz FM subcarrier	T			T		X		
4-3.3.3.4	AM with 30 Hz	T	T				X		
4-3.3.3.5	RF output circuit	T					X		
4-3.3.3.6.1	Power output calibration	T			T		X		
4-3.3.3.7.1	Amplitude modulation	T		T			X		TYPE TEST-1FREQ
4-3.3.3.7.1.1	Amplitude level and stability	T					X		
4-3.3.3.7.1.2	Phase stability for 30 Hz	T					X		
4-3.3.3.8.1	RF tuning adjustments	D					X		

VERIFICATION METHOD: INSPECTION-I, ANALYSIS-A, TEST-T, DEMONSTRATION-D

TABLE 2

VOR/DME SYSTEM - VERIFICATION REQUIREMENT TRACEABILITY MATRIX

REQUIREMENTS		TEST LEVEL AND METHOD					TEST LOCATION		REMARKS
PARAGRAPH NUMBER	TITLE	FIRST ARTICLE DESIGN QUALIFICATION	TYPE TEST NORMAL CONDITIONS	TYPE TEST SERVICE CONDITIONS	PRODUCTION TESTS	OPERATIONAL SHAKEDOWN	FACTORY	ASM-150/ ACT	
3-3.3.3.1.1	Data transmission	D					X		
3-3.3.3.2	Input transformer	I					X		
3-3.3.4	Voice identification	T					X		
3-3.3.4.1	Voice recording function	D					X		
3-3.3.4.2	Erase function	D					X		
3-3.3.4.3	Frequency response	T			T		X		
3-3.3.4.4	Signal to noise ratio	T					X		
3-3.3.4.6	Output level	T					X		
3-3.3.4.7	Nonvolatility	A					X		
3-3.3.4.8	Alternate voice input	A,D,T					X		
3-3.5	FCPU fail-safe requirements	T			T		X		DQT-3 FREQ
4-3.3.3.1	Carrier power output	T		T			X		DQT-3 FREQ
4-3.3.3.1.1	Carrier power output level stability and control	T		T			X		DQT-3 FREQ
4-3.3.3.1.2	Stabilization of performance characteristics	T					X		
4-3.3.3.2	Output signal spectrum	T			T		X		
4-3.3.3.3	AM with 9960 Hz FM subcarrier	T			T		X		
4-3.3.3.4	AM with 30 Hz	T	T				X		
4-3.3.3.5	RF output circuit	T					X		
4-3.3.3.6.1	Power output calibration	T			T		X		
4-3.3.3.7.1	Amplitude modulation	T		T			X		TYPE TEST-1FREQ
4-3.3.3.7.1.1	Amplitude level and stability	T					X		
4-3.3.3.7.1.2	Phase stability for 30 Hz	T					X		
4-3.3.3.8.1	RF tuning adjustments	D					X		

VERIFICATION METHOD: INSPECTION - I, ANALYSIS - A, TEST - T, DEMONSTRATION - D

TABLE 2

VOR/DME SYSTEM-VERIFICATION REQUIREMENT TRACEABILITY MATRIX

REQUIREMENTS		TEST LEVEL AND METHOD					TEST LOCATION		REMARKS
PARAGRAPH NUMBER	TITLE	FIRST ARTICLE DESIGN QUALIFICATION	TYPE TEST NORMAL CONDITIONS	TYPE TEST SERVICE CONDITIONS	PRODUCTION TESTS	OPERATIONAL SHAKEDOWN	FACTORY	ASM-150/ ACT	
4-3.3.4.3.8	Deviation from average envelope amplitude			T			X		
4-3.3.4.3.9	Output circuit loading			T			X		
4-3.3.4.3.10	Power output during warm up			T			X		
4-3.3.4.4.1	Mean frequency stability			T			X		
4-3.3.4.4.2	Phase control and stability			T			X		
4-3.3.4.4.4	Frequency deviation			T			X		
4-3.3.4.4.6	Amplitude modulation			T			X		
4-3.3.5	External input	D					X		
4-3.4	Stray radiation		T				X		
5-3.3.4	30 Hz AM and 30 Hz FM test point isolation	T					X		
5-3.3.6	Ground check	D			X	D	X	X	
5-3.3.7.1	Broadband characteristics	D					X		
5-3.3.7.2	Phase balance	T					X		
5-3.3.7.3	Polarization	T					X		
5-3.3.7.4	Dipole antenna	I					X		
5-3.3.7.5	Antenna mast	I					X		
5-3.3.7.5.1	Mast surface	I					X		
5-3.3.7.5.2	Mast cable slot	I					X		
5-3.3.7.5.3	Cable clamp	I					X		
5-3.3.7.5.4	Protective enclosure	I					X		
5-3.3.7.7	Nameplate	I					X		
5-3.3.7.8	Monitor antenna extension mast	I					X		
5-3.3.8.3.1	Level control	D					X		

VERIFICATION METHOD: INSPECTION-I, ANALYSIS-A, TEST-T, DEMONSTRATION-D

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TABLE 2

VOR/DME SYSTEM-VERIFICATION REQUIREMENT TRACEABILITY MATRIX

REQUIREMENTS		TEST LEVEL AND METHOD					TEST LOCATION		REMARKS
PARAGRAPH NUMBER	TITLE	FIRST ARTICLE DESIGN QUALIFICATION	TYPE TEST NORMAL CONDITIONS	TYPE TEST SERVICE CONDITIONS	PRODUCTION TESTS	OPERATIONAL SHAKEDOWN	FACTORY	ASM-150/ ACT	
5-3.3.8.3.2	Effect on monitored signal	T					X		
5-3.3.8.3.3.2	Output power	T					X		
5-3.3.8.3.3.3	Output stability			T			X		
5-3.3.8.3.4	Frequency response	T					X		
5-3.3.8.3.5	Audio distortion	T					X		
5-3.3.8.3.6	Hum and noise	T					X		
5-3.3.8.3.7.1	Output power	T					X		
5-3.3.8.4	Isolation from 30 Hz AM signal	T					X		
5-3.3.8.5	Detector signal harmonics	T					X		
5-3.3.8.6.1	Azimuth selection	D					X		
5-3.3.8.7	Zero adjustment	D					X		
5-3.3.8.8	Accuracy of azimuth indication	T		T	T		X		
5-3.3.8.8.1	Stability with changes in signal frequency	T	T				X		
5-3.3.8.8.2	Stability with changes in AC line voltage	T					X		
5-3.3.8.8.3	Stability with voice signal applied	T					X		
5-3.3.8.9.1	Azimuth fault	T			T		X		
5-3.3.8.9.2	30 Hz AM modulator fault	T			T		X		
5-3.3.8.9.3	FM sub carrier modulation fault	T			T		X		
5-3.3.8.9.4	FM sub carrier frequency deviation fault	T			T		X		
5-3.3.8.9.5	Identification fault	T			T		X		
5-3.3.8.9.6	Field intensity fault	T			T		X		
5-3.3.8.9.7	Main alarm output	T					X		
5-3.3.8.9.7.1	Alarm bypass control	D					X		

VERIFICATION METHOD: INSPECTION-I, ANALYSIS-A, TEST-T, DEMONSTRATION-D

TABLE 2

VOR/DME SYSTEM-VERIFICATION REQUIREMENT TRACEABILITY MATRIX

REQUIREMENTS		TEST LEVEL AND METHOD					TEST LOCATION		REMARKS
PARAGRAPH NUMBER	TITLE	FIRST ARTICLE DESIGN QUALIFICATION	TYPE TEST NORMAL CONDITIONS	TYPE TEST SERVICE CONDITIONS	PRODUCTION TESTS	OPERATIONAL SHAKEDOWN	FACTORY	ASM-150/ ACT	
5-3.3.8.3.2	Effect on monitored signal	T					X		
5-3.3.8.3.3.2	Output power	T					X		
5-3.3.8.3.3.3	Output stability			T			X		
5-3.3.8.3.4	Frequency response	T					X		
5-3.3.8.3.5	Audio distortion	T					X		
5-3.3.8.3.6	Hum and noise	T					X		
5-3.3.8.3.7.1	Output power	T					X		
5-3.3.8.4	Isolation from 30 Hz AM signal	T					X		
5-3.3.8.5	Detector signal harmonics	T					X		
5-3.3.8.6.1	Azimuth selection	D					X		
5-3.3.8.7	Zero adjustment	D					X		
5-3.3.8.8	Accuracy of azimuth indication	T		T	T		X		
5-3.3.8.8.1	Stability with changes in signal frequency	T	T				X		
5-3.3.8.8.2	Stability with changes in AC line voltage	T					X		
5-3.3.8.8.3	Stability with voice signal applied	T					X		
5-3.3.8.9.1	Azimuth fault	T			T		X		
5-3.3.8.9.2	30 Hz AM modulator fault	T			T		X		
5-3.3.8.9.3	FM sub carrier modulation fault	T			T		X		
5-3.3.8.9.4	FM sub carrier frequency deviation fault	T			T		X		
5-3.3.8.9.5	Identification fault	T			T		X		
5-3.3.8.9.6	Field intensity fault	T			T		X		
5-3.3.8.9.7	Main alarm output	T					X		
5-3.3.8.9.7.1	Alarm bypass control	D					X		

VERIFICATION METHOD: INSPECTION-I, ANALYSIS-A, TEST-T, DEMONSTRATION-D

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VOR/DME SYSTEM-VERIFICATION REQUIREMENT TRACEABILITY MATRIX

REQUIREMENTS		TEST LEVEL AND METHOD					TEST LOCATION		REMARKS
PARAGRAPH NUMBER	TITLE	FIRST ARTICLE DESIGN QUALIFICATION	TYPE TEST NORMAL CONDITIONS	TYPE TEST SERVICE CONDITIONS	PRODUCTION TESTS	OPERATIONAL SHAKEDOWN	FACTORY	ASM-150/ ACT	
6-3.4.3.7.1.3	Desensitization by adjacent channel	T		T	T		X		
6-3.4.3.7.1.4	Desensitization by CW			T	T		X		
6-3.4.3.7.1.5	Desensitization by high repetition rate			T	T		X		
6-3.4.3.7.2	Sensitivity to adjacent channel	D					X		
6-3.4.3.7.3	Reply delay time variation			T	T		X		
6-3.4.3.7.4	Pulse width discrimination			T	T		X		
6-3.4.3.8.1	Present duty cycle			T	T		X		
6-3.4.3.8.2	Increased traffic handling			T	T		X		
6-3.4.3.9	Interference suppression	T			T		X		
6-3.4.3.10	Random squitter pulses			T	T		X		
6-3.4.3.10.1	Priority of reply pulses	T					X		
6-3.4.3.11	Pulse rate control	D					X		
6-3.4.3.11.1	Effect of traffic loading			T			X		
6-3.4.3.12	Automatic gain reduction		T				X		
6-3.4.3.12.1	Interrogation overload signal	T					X		
6-3.4.4.1	Priority of transmission	D					X		
6-3.4.4.2	Reply pulse coding	D					X		
6-3.4.4.3	Reply delay	D					X		
6-3.4.4.4	Identification signal	D					X		
6-3.4.5	Identification keying	T		T			X		
6-3.4.6.1.1.1	Pulse rise time	A,D,T					X		
6-3.4.6.1.1.2	Pulse top	D					X		
6-3.4.6.1.1.3	Pulse duration	D					X		

VERIFICATION METHOD: INSPECTION-I, ANALYSIS-A, TEST-T, DEMONSTRATION-D

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VOR/DME SYSTEM-VERIFICATION REQUIREMENT TRACEABILITY MATRIX

REQUIREMENTS		TEST LEVEL AND METHOD					TEST LOCATION		REMARKS
PARAGRAPH NUMBER	TITLE	FIRST ARTICLE DESIGN QUALIFICATION	TYPE TEST NORMAL CONDITIONS	TYPE TEST SERVICE CONDITIONS	PRODUCTION TESTS	OPERATIONAL SHAKEDOWN	FACTORY	ASM-150/ ACT	
6-3.4.6.1.1.4	Pulse decay time			T	T		X		
6-3.4.6.1.2	Power output	T			T		X		
6-3.4.6.1.3	Pulse power variation			T	T		X		
6-3.4.6.1.4	RF output control	T					X		
6-3.4.6.1.5	Tuning and spurious output	D					X		
6-3.4.6.16	RF pulse signal spectrum			T			X		
6-3.4.6.1.7	Spurious output		T				X		
6-3.4.6.1.8	Inter-pulse output level	T					X		
6-3.4.6.1.9	Retriggering of transponder	D					X		
6-3.4.6.1.10	Duty cycle	D					X		
6-3.4.6.1.11	Duty cycle overload protection	D					X		
6-3.4.6.2	Thermal protection	D					X		
7-3.3.3	Stabilization of performance characteristics	T					X		
7-3.3.4	Fail - safe operation	A,D,T					X		
7-3.4.1	Operating channels	D					X		
7-3.4.1.1	Broadband operation	D					X		
7-3.4.1.2	RF tuning	D					X		
7-3.4.1.3	Channel frequency accuracy and stability	T		T			X		See 1-3.3.14.1
7-3.4.2.2.1	Antenna transmission line/transponder output	D					X		
7-3.4.2.2.1.1	RF input levels	D					X		
7-3.4.2.2.2.1	DME antenna coupling probes	T					X		
7-3.4.2.3	Directional couplers	T		T			X		
7-3.4.3	Key monitored signal parameters	T			T	T	X	X	

VERIFICATION METHOD: INSPECTION-I, ANALYSIS-A, TEST-T, DEMONSTRATION-D

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VOR/DME SYSTEM-VERIFICATION REQUIREMENT TRACEABILITY MATRIX

REQUIREMENTS		TEST LEVEL AND METHOD					TEST LOCATION		REMARKS
PARAGRAPH NUMBER	TITLE	FIRST ARTICLE DESIGN QUALIFICATION	TYPE TEST NORMAL CONDITIONS	TYPE TEST SERVICE CONDITIONS	PRODUCTION TESTS	OPERATIONAL SHAKEDOWN	FACTORY	ASM-150/ ACT	
6-3.4.6.1.1.4	Pulse decay time			T	T		X		
6-3.4.6.1.2	Power output	T			T		X		
6-3.4.6.1.3	Pulse power variation			T	T		X		
6-3.4.6.1.4	RF output control	T					X		
6-3.4.6.1.5	Tuning and spurious output	D					X		
6-3.4.6.16	RF pulse signal spectrum			T			X		
6-3.4.6.1.7	Spurious output		T				X		
6-3.4.6.1.8	Inter-pulse output level	T					X		
6-3.4.6.1.9	Retriggering of transponder	D					X		
6-3.4.6.1.10	Duty cycle	D					X		
6-3.4.6.1.11	Duty cycle overload protection	D					X		
6-3.4.6.2	Thermal protection	D					X		
7-3.3.3	Stabilization of performance characteristics	T					X		
7-3.3.4	Fail - safe operation	A,D,T					X		
7-3.4.1	Operating channels	D					X		
7-3.4.1.1	Broadband operation	D					X		
7-3.4.1.2	RF tuning	D					X		
7-3.4.1.3	Channel frequency accuracy and stability	T		T			X		See 1-3.3.14.1
7-3.4.2.2.1	Antenna transmission line/transponder output	D					X		
7-3.4.2.2.1.1	RF input levels	D					X		
7-3.4.2.2.2.1	DME antenna coupling probes	T					X		
7-3.4.2.3	Directional couplers	T		T			X		
7-3.4.3	Key monitored signal parameters	T			T	T	X	X	

VERIFICATION METHOD: INSPECTION-I, ANALYSIS-A, TEST-T, DEMONSTRATION-D

TABLE 2

VOR/DME SYSTEM-VERIFICATION REQUIREMENT TRACEABILITY MATRIX

REQUIREMENTS		TEST LEVEL AND METHOD					TEST LOCATION		REMARKS
PARAGRAPH NUMBER	TITLE	FIRST ARTICLE DESIGN QUALIFICATION	TYPE TEST NORMAL CONDITIONS	TYPE TEST SERVICE CONDITIONS	PRODUCTION TESTS	OPERATIONAL SHAKEDOWN	FACTORY	ASM-150/ ACT	
8-3.3.2.3	Output phase			T	T		X		
8-3.3.2.5	9960 Hz reference frequency						X		
8-3.3.2.6	Output signal spectrum	[illegible]	[illegible]				X		
8-3.3.2.7	Carrier to sideband isolation	[illegible]	[illegible]				X		
8-3.3.2.8	Cross channel isolation	[illegible]	[illegible]				X		
8-3.3.2.9	Stray radiation	[illegible]					X		
8-3.3.3.1	Distribution function						X		
8-3.3.3.1.1	Blending function				T		X		
8-3.3.3.2	Insertion loss	[illegible]					X		
8-3.3.3.3	RF phase shift	[illegible]			T		X		
8-3.3.3.4	RF output waveform	[illegible]		T			X		
8-3.3.3.5	Switching isolation	[illegible]			T		X		
8-3.3.3.6.1	Frequency stability	[illegible]	[illegible]				X		
8-3.3.3.6.2	Phase stability		[illegible]				X		
8-3.3.3.6.3	Output level and stability		[illegible]				X		
8-3.3.3.7	Master generator oscillator		[illegible]				X		
8-3.3.3.7.1	Phase adjust	[illegible]					X		
8-3.3.3.8	Stray radiation	[illegible]					X		
9-3.2.1.2	Communications unit	[illegible]					X		
9-3.2.1.2.1	Dual voice interface	[illegible]				[illegible]	X	X	
9-3.2.2	RSCE processing unit	[illegible]				[illegible]	X	X	
9-3.2.2.1	RSCE interfaces	[illegible]			T	[illegible]	X	X	Fail-safe D
9-3.2.2.1	RSCE failsafe	[illegible]				[illegible]	X	X	

VERIFICATION METHOD: INSPECTION-I, ANALYSIS-A TEST-T DEMONSTRATION-D

TABLE 2

VOR/DME SYSTEM-VERIFICATION REQUIREMENT TRACEABILITY MATRIX

REQUIREMENTS		TEST LEVEL AND METHOD					TEST LOCATION		REMARKS
PARAGRAPH NUMBER	TITLE	FIRST ARTICLE DESIGN QUALIFICATION	TYPE TEST NORMAL CONDITIONS	TYPE TEST SERVICE CONDITIONS	PRODUCTION TESTS	OPERATIONAL SHAKEDOWN	FACTORY	ASR-150/ ACT	
-3.3	Equipment Construction						X		
-3.4.1	Functions	I					X		
-3.4.2	Construction	I					X		

VERIFICATION METHOD: INSPECTION-I, ANALYSIS-A, TEST-T, DEMONSTRATION-D

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TABLE 2

VOR/DME SYSTEM-VERIFICATION REQUIREMENT TRACEABILITY MATRIX

REQUIREMENTS		TEST LEVEL AND METHOD					TEST LOCATION		REMARKS
PARAGRAPH NUMBER	TITLE	FIRST ARTICLE DESIGN QUALIFICATION	TYPE TEST NORMAL CONDITIONS	TYPE TEST SERVICE CONDITIONS	PRODUCTION TESTS	OPERATIONAL SHAKEDOWN	FACTORY	ASR-150/ ACT	
-3.3	Equipment Construction						X		
-3.4.1	Functions	I					X		
-3.4.2	Construction	I					X		

VERIFICATION METHOD: INSPECTION-I, ANALYSIS-A, TEST-T, DEMONSTRATION-D

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

VOR/DME EQUIPMENT
PART 2 - BATTERY CHARGER POWER SUPPLY (BCPS)

2-1 SCOPE - BATTERY CHARGER POWER SUPPLY (BCPS)

2-1.1 Scone of Part 2.- This Part 2 is one of a group of specification documents under the basic heading "VOR/DME Equipment", each of which carries the basic number FAA-E-2678 together with an alpha revision letter and a slant line and number corresponding to the Part number. This Part 2 covers requirements for the Battery Charger Power Supply (BCPS) to be furnished as part of the equipment defined in Part 1 of this specification. The BCPS shall provide support and backup for the primary DC battery uninterruptable power to equipments described in Parts 2 through 7 of this specification and additionally for the charging of battery bank(s) (batteries are not required to be furnished under this specification) to provide for continuous operation upon loss of station AC input power.

-1.2 Limitation of Part 2.- This Part 2 does not completely define the requirements for physical and electrical interface with other elements covered under other parts of this specification, these being the responsibility of the contractor. Additionally, certain requirements are defined only by reference to other parts of the specification.

2-2 APPLICABLE DOCUMENTS.- (See paragraph 1-2 of Part 1.)

2-3 REQUIREMENTS

2-3.1 Equipment to be furnished by the contractor.- Each BCPS shall be complete and in accordance with all specification requirements. Each BCPS shall be completely wired and ready for operation upon connections of AC power, a battery bank (not required to be furnished under this specification) and external control cables. When the equipment is properly connected to the Government furnished battery bank, it shall constitute an uninterruptable power source (UPS).

2-3.1.1 Utilization.- Each set of equipment furnished under paragraph 1-3.2.1 of Part 1 of this specification shall include one each, BCPS.

2-3.2 Definitions.-

2-3.2.1 Uninterruptable power source.- A DC power source which maintains continuous operation with no switching when AC power is interrupted. This utilizes battery float techniques.

2-3.2.2 Battery float.- Operation of all equipment shall be connected to a battery DC source in such a manner that the system is independent of the presence or absence of AC power. The BCPS shall be supportive of the battery.

2-3.3 Equipment basic requirements.- (See paragraph 1-3.3 of Part 1).

2-3.3.1 Equipment physical design and packaging.- (See paragraph 1-3.3.1 of Part 1.) The BCPS shall be housed in one of the two (maximum) cabinets provided in the equipment configuration required under paragraph 1-3.2.1 of Part 1.

2-3.3.2 Modular construction.- (See paragraph 1-3.3.1.5 of Part 1.)

2-3.3.3 Primary power source.- (See paragraph 1-3.3.16 of Part 1.)

2-3.3.4 Transient suppression.- (See paragraph 1-3.3.17 of Part 1.)

2-3.3.5 DC output voltage.- The DC output voltage of the BCPS (nominal DC input voltage of equipment items furnished under Parts 3 through 7 of this specification) shall be a value which is an integral multiple of 12 volts, but not to exceed 60 volts. The system designer shall establish tolerances for output voltage variation, ripple, etc., consistent with the requirements of the equipment items to be supplied.

2-3.3.5.1 48 volt supply.- In addition to the output voltage of 2-3.3.5 above the BCPS shall provide a 48 volt source for operation of up to ten relays as described in paragraph 3-3.3.2.9.3 of Part 3 of this specification. For this application, each 48 volt relay will require 40 milliamperes.

2-3.3.6 Output capacity.- The BCPS shall be of Sufficient capacity to furnish DC power for normal battery float operation and equalize voltage, as required, for the equipment configuration of paragraph 1-3.2.1. specifically, adequate current shall be produced to simultaneously power a VOR, DME, associated monitor(s), and built-in test equipment. The power required for the DME final amplifier is permitted to be derived from AC power.

2-3.2 Definitions.-

2-3.2.1 Uninterruptable power source.- A DC power source which maintains continuous operation with no switching when AC power is interrupted. This utilizes battery float techniques.

2-3.2.2 Battery float.- Operation of all equipment shall be connected to a battery DC source in such a manner that the system is independent of the presence or absence of AC power. The BCPS shall be supportive of the battery.

2-3.3 Equipment basic requirements.- (See paragraph 1-3.3 of Part 1).

2-3.3.1 Equipment physical design and packaging.- (See paragraph 1-3.3.1 of Part 1.) The BCPS shall be housed in one of the two (maximum) cabinets provided in the equipment configuration required under paragraph 1-3.2.1 of Part 1.

2-3.3.2 Modular construction.- (See paragraph 1-3.3.1.5 of Part 1.)

2-3.3.3 Primary power source.- (See paragraph 1-3.3.16 of Part 1.)

2-3.3.4 Transient suppression.- (See paragraph 1-3.3.17 of Part 1.)

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2-3.3.11 Reliability.- (See 1-3.4 of Part 1.)

2-4 QUALITY ASSURANCE.- (See 1-4 of Part 1.)

2-5 PREPARATION FOR DELIVERY.- (See 1-5 of Part 1.)

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

VOR/DME EQUIPMENT
PART 3 - FACILITY CENTRAL PROCESSING UNIT (FCPU)

3-1 SCOPE - FACILITY CENTRAL PROCESSING UNIT (FCPU)

3-1.1 Scope of Part 3.- This Part 3 is one of a group of specification documents under the basic heading "VOR/DME Equipment", each of which carries the basic number FAA-E-2678 together with an alpha revision letter and a slant line and number corresponding to the Part number. Part 3 of the specification covers the requirements for the facility central processing unit (FCPU) to be furnished as part of a set of equipment as defined in Part 1. The FCPU makes the determination of the status of all monitors (VOR and DME) through the initiation of automatic limit tests upon monitor discrepancies and periodically for certification verification (3-3.3.2.4 and 3-3.3.2.5). The FCPU stores and transmits all data available for use at a remote site (see FAA-E-2678c/9). The FCPU software stores all data (faults, alarms, and shutdowns) for future availability and historical record keeping.

3-1.2 Limitations of Part 3.- This Part 3 does not completely define the requirements for physical and electrical interface with other equipment elements covered under other parts of the specification, these being the responsibility of the contractor Additionally, certain requirements are defined only through references to other parts of the specification.

3-2 APPLICABLE DOCUMENTS.- (See Paragraph 1-2 of Part 1.)

3-3 REQUIREMENTS

3-3.1 Equipment to be furnished by the contractor.- Each VOR/DME system to be provided under this specification shall include a facility central processing unit (FCPU) complete and in accordance with all of the requirements of this specification.

3-3.2 Definitions.- The following definitions define non-standard technical terms and/or special terms that form a part of this specification.

3-3.2.1 Operating tolerance/limit.- The operating tolerance/ limit is the maximum deviation or the range from the standard

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

VOR/DME EQUIPMENT
PART 3 - FACILITY CENTRAL PROCESSING UNIT (FCPU)

3-1 SCOPE - FACILITY CENTRAL PROCESSING UNIT (FCPU)

3-1.1 Scope of Part 3.- This Part 3 is one of a group of specification documents under the basic heading "VOR/DME Equipment", each of which carries the basic number FAA-E-2678 together with an alpha revision letter and a slant line and number corresponding to the Part number. Part 3 of the specification covers the requirements for the facility central processing unit (FCPU) to be furnished as part of a set of equipment as defined in Part 1. The FCPU makes the determination of the status of all monitors (VOR and DME) through the initiation of automatic limit tests upon monitor discrepancies and periodically for certification verification (3-3.3.2.4 and 3-3.3.2.5). The FCPU stores and transmits all data available for use at a remote site (see FAA-E-2678c/9). The FCPU software stores all data (faults, alarms, and shutdowns) for future availability and historical record keeping.

3-1.2 Limitations of Part 3.- This Part 3 does not completely define the requirements for physical and electrical interface with other equipment elements covered under other parts of the specification, these being the responsibility of the contractor Additionally, certain requirements are defined only through references to other parts of the specification.

3-2 APPLICABLE DOCUMENTS.- (See Paragraph 1-2 of Part 1.)

3-3 REQUIREMENTS

3-3.1 Equipment to be furnished by the contractor.- Each VOR/DME system to be provided under this specification shall include a facility central processing unit (FCPU) complete and in accordance with all of the requirements of this specification.

3-3.2 Definitions.- The following definitions define non-standard technical terms and/or special terms that form a part of this specification.

3-3.2.1 Operating tolerance/limit.- The operating tolerance/ limit is the maximum deviation or the range from the standard

3-3.2.13 Remote monitoring subsystem (RMS) software.- The RMS software is the software program resident in memory that is required to perform data collection of the system.

3-3.2.14 Periodic data.- Periodic data is data accessible via the data buss or memory or upon periodic program or request. This includes the data necessary for fault diagnosis and trend analysis.

3-3.2.15 Maintenance monitoring.- The information provided for maintenance monitoring consists of qualitative and quantitative data on the actual performance and/or status of the VOR/DME systems including any individual elements thereof. This data may be used for certification, trend analysis or fault isolation purposes. The transmittal of maintenance monitoring data is not required to be continuous but shall be programmed for periodic transmission, transmission upon occasion of faults and transmission upon request. Maintenance monitoring also includes the ability to control system operation, control test equipment for checking the operational status, verifying and setting monitor alarm limits and changing certain operational characteristics of the systems.

3-3.2.16 Portable maintenance data terminal (PMDT).- The term PMDT as used herein is defined as a commercially available, IBM compatible portable terminal with keyboard, monitor and printer and as further described in the contract schedule.

3-3.3 FCPU functions.- The FCPU performs or provides the three interrelated functions listed below.

(a) VOR/DME remote monitoring subsystem (RMS) functions as defined in Interface Control Document (ICD) NAS-MD-790 and as further defined herein.

(b) Provides adjustment, testing and control capabilities of the VOR/DME equipment through appropriate equipment and external interfaces.

(c) Manages voice and data communications between the VOR/DME equipment units and the remote status and communications equipment (RSCE). Manages the data communications between the VOR/DME equipment units and the maintenance processor subsystem (MPS). The MPS is not to be furnished under this specification.

3-3.3.1 VOR/DME RMS.- The VOR/DME RMS consists of the various sensors, microcomputers, built-in test equipment (BITE) and microprocessor controlled equipment necessary to locally and remotely monitor, control, record and certify proper operation of the equipment units comprising the VOR/DME systems to be furnished under this specification. It includes the FCPU, the environmental sensors to be furnished in accordance with paragraphs 3-3.3.2.10 through 3-3.3.2.10.5 herein and the various embedded sensors required for sampling signals from the VOR/DME equipment units. It shall be designed in accordance with Interface Control Document (ICD) NAS-MD-790 and the additional requirements specified herein. Operational requirements for the VOR/DME RMS are given in NAS-MD-792. Functional requirements for the VOR/DME RMS are given in NAS-MD-793.

3-3.3.1.1 VOR/DME RMS functions. - The VOR/DME RMS shall provide the following functions:

(a) Monitor each of the minimum set of performance parameters required to determine the operational status of all VOR/DME equipment units. The monitor data shall be accumulated on a periodic basis: all monitor data and alarm data shall be collected and maintained on a time - date basis as historical files.

(b) Process the outputs of each of the monitoring devices as necessary to provide digital signals to the RSCE interface in the formats defined in NAS-MD-790. This digital data shall represent the engineering units monitored and require no further correction or mathematical calculation before being displayed.

(c) Process the outputs of each of the monitoring devices to determine alarm and alert status by comparing the monitored outputs to predetermined limits. These limits shall be changeable through the software program over the entire range of the measured parameter. Alarm messages and alert messages shall not be set and reset within a range equal to two times the minimum resolution of the parameter being monitored above and below the programmed thresholds. Not less than two thresholds shall be provided for each monitored parameter. Messages shall be generated and provided to the RSCE interface in the formats required by NAS-MD-790.

(d) Perform VOR/DME subsystem fault diagnostics in accordance with the requirements of paragraph 1-3.3.7

(e) Upon request from the PMDT interface or from the MPS, the RMS shall provide the current value of each parameter in the group or groups of parameters indicated by the content of the request message. Any given request may identify a single parameter, an entire preprogrammed list of parameters, a group of randomly selected parameters, or all groups of the monitored parameters.

(f) Provide a "pass-through" function which provides the capability to pass messages up to 4000 characters in length from the MPS. This capability shall supply any additional processing or formatting, or both, required to interface with the communications subsystem.

(g) Provide storage capabilities sufficient to store the current status of alarms and alerts, data values, alarm and alert thresholds, operator menus, and program instructions necessary to support interface functions on the MPS and test routines needed to meet the maintainability requirements of (d) above.

(h) Failure in the RMS shall not propagate, i.e., cause failures in, or in any way degrade the air traffic operational capabilities of the VOR/DME system.

(i) In addition to the Startup/Recovery Command of paragraph 3.7.2 of NAS-MD-790, the RMS shall respond to a Master Shutdown command issued from the MPS interface which will cause the VOR/DME systems to shut down without delay.

3-3.3.1.2 FCPU interfaces.- The FCPU provides a central point for communications between the VOR/DME equipment and the RSCE and thence to the MPS. It shall contain the interfaces listed in the following subparagraphs.

3-3.3.1.2.1 FCPU to RSCE interface.- The FCPU to RSCE interface shall be in accordance with EIA standard RS-232 wired as synchronous data terminal equipment (DTE). It shall interface through a contractor provided commercially available voice over data modem with the Government furnished 4 wire telephone line described in paragraph 1-3.3.13.1. The interface shall operate at a minimum rate of 1200 baud.

3-3.3.1.2.2 Portable maintenance data terminal (PMDT) interface.- (See paragraph 3-3.2.16.) The PMDT interface shall be in accordance with EIA Standard RS-232, wired as asynchronous, data communication equipment (DCE), full duplex, 25 pin, type D interface. The PMDT interface shall use eight bit, no parity and shall automatically adjust to baud rates of 2400, 4800, 9600. The interface shall be wired to a front panel mounted female MIL-C-24308 (MS-18275) connector. ASCII characters received via the PMDT interface shall also be transmitted via the PMDT interface, i.e., echoed as the characters are received. The PMDT interface protocol, to be approved by the Government, shall be commercially available,

3-3.3.1.3 PMDT interface commands.- With the PMDT in local mode commands shall be provided to support the man-machine interface through the use of a terminal. Each command shall consist of command mnemonic or character followed by the arguments required for the command, and terminated by the ASCII character CR (carriage return). The commands provided shall support the following capabilities as a minimum:

(a) Print and display menu of available commands.

(b) Print the measured value of any selected parameter measured at programmable intervals. The length of the intervals shall be programmable from 10 seconds to 60 seconds in 10 second increments.

(c) Transmit terminal messages to the MPS.

(d) Automatically print the content of any message addressed to that terminal.

(e) Print the status of the transmitter, transponder and the monitors.

(f) Execute the VOR/DME diagnostic routines.

3-3.3.1.4 Protocol.- The protocol used to control the FCPU to RSCE data interface shall be in accordance with ANSI-X 3.66, American National Standard for Advanced Data Communication Control Procedures (ADCCP) and NAS-MD-790.

The voice/data interface between the FCPU and the RSCE shall require the utilization of audio frequency shift keying (AFSK), phase shift keying (PSK) or other similar commercially available techniques that will result in data transmission of at least a 1200 baud rate while maintaining intelligible, and recognizable voice between 300 and 3000 Hz.

3-3.3.1.5 Memory.- Memory shall consist of the appropriate combinations of read-only memory (ROM), programmable read-only memory (PROM), erasable programmable read-only memory (EPROM) and random-access memory (RAM). The basic PROM or EPROM device shall be available to the Government as a commercially available off-the-shelf item.

The FCPU shall have expansion capabilities sufficient to increase the memory capacity to 150% of that which is originally required to meet the functional requirements specified herein. This expansion shall not require any rewiring of existing assemblies. At least four spare card slots shall be provided for expansion capability.

3-3.3.1.6 Volatility.- Storage of all control settings, operational parameters and limits, all initialization data, all data files and fault history shall be provided in non-volatile through the use of a terminal. Each command shall consist of command mnemonic or character followed by the arguments required for the command, and terminated by the ASCII character CR (carriage return). The commands provided shall support the following capabilities as a minimum:

(a) Print and display menu of available commands.

(b) Print the measured value of any selected parameter measured at programmable intervals. The length of the intervals shall be programmable from 10 seconds to 60 seconds in 10 second increments.

(c) Transmit terminal messages to the MPS.

(d) Automatically print the content of any message addressed to that terminal.

(e) Print the status of the transmitter, transponder and the monitors.

(f) Execute the VOR/DME diagnostic routines.

3-3.3.1.4 Protocol.- The protocol used to control the FCPU to RSCE data interface shall be in accordance with ANSI-X 3.66, American National Standard for Advanced Data Communication Control Procedures (ADCCP) and NAS-MD-790.

The voice/data interface between the FCPU and the RSCE shall require the utilization of audio frequency shift keying (AFSK), phase shift keying (PSK) or other similar commercially available techniques that will result in data transmission of at least a 1200 baud rate while maintaining intelligible, and recognizable voice between 300 and 3000 Hz.

3-3.3.1.5 Memorv.- Memory shall consist of the appropriate combinations of read-only memory (ROM), programmable read-only memory (PROM), erasable programmable read-only memory (EPROM) and random-access memory (RAM). The basic PROM or EPROM device shall be available to the Government as a commercially available off-the-shelf item.

The FCPU shall have expansion capabilities sufficient to increase the memory capacity to 150% of that which is originally required to meet the functional requirements specified herein. This expansion shall not require any rewiring of existing assemblies. At least four spare card slots shall be provided for expansion capability.

3-3.3.1.6 Volatilitv.- Storage of all control settings, operational parameters and limits, all initialization data, all data files and fault history shall be provided in non-volatile

3-3.3.1.12 Data communications failures.- When data communication failures between the FCPU and the MPS occur, the procedures of paragraph 3.8 of NAS-MD-790 shall be implemented. Additionally, the VOR/DME RMS shall initiate automatic storage of all data (faults, alarms and shutdowns) for future availability and record keeping purposes.

3-3.3.1.13 Interface control document (ICD) - The contractor shall prepare an ICD in accordance with the applicable provisions of FAA-STD-025 and as specified in paragraph 1.3 of NAS-MD-790. The contractor prepared ICD shall define all pertinent information required to interface the RMS with the MPS, provide data communications and other functions required by this specification. As stated in paragraph 1.3 of NAS-MD-790, the ICD shall not restate or rewrite the contents of NAS-MD-790. Additionally, the ICD shall provide the applicable information required by paragraphs 1.3, 3.1.2, 3.1.2.d, 3.1.3.d, 3.3.3.2, 3.6 and 3.7 of NAS-MD-790. Equipment internal ICDs shall be provided by the contractor as specified in paragraph 3-3.4.5.1 and FAA-STD-025.

3-3.3.2 FCPU adjustment, and testing and control.- The FCPU shall provide the capability through the FCPU to equipment interface for the adjustment of all VOR/DME equipment controls, testing and control of VOR/DME equipment and the ability to test external systems not to be furnished under this specification.

3-3.3.2.1 VOR/DME equipment adjustments.- The FCPU to equipment interface shall be such that the adjustment of all VOR/DME equipment controls required for routine and corrective maintenance, VOR/DME certification and the indications thereof shall be accessible locally via the PMDT interface or remotely from the MPS Procedures must be provided to ensure that the security requirements of paragraph 3-3.3.1.11 herein are not violated.

3-3.3.2.2 VOR/DME equipment testing.- The FCPU to equipment interface shall be such that all routine or corrective maintenance testing required to certify proper operation of the VOR/DME equipment is available locally to the PMDT interface or is available remotely from the MPS.

3-3.3.2.2.1 Test equipment.- The following test equipment functions shall be provided in the FCPU for use with the VOR. The exercising of these functions for test purposes shall be controlled locally by the PMDT or remotely from the MPS.

3.3.2.3 VOR test generator functions.- Test generator functions shall be incorporated within the FCPU equipment.

3-3.3.2.3.1 Frequency modulation (FM) Signal.- The FM subcarrier shall meet the requirements of the following subparagraphs.

3-3.3.2.3.1.1 FM subcarrier frequency.- The nominal frequency of the FM subcarrier signal shall be 9960 Hz, frequency modulated ±480 (±8 Hz) by a 30 Hz sinusoid. The frequency deviation shall be adjustable to 9960 ±360 Hz through 9960 ±600 Hz, as a minimum, in increments of 10 Hz or less and with stability of ±4 Hz once set. The increasing 9960 frequency represents the positive going 30 Hz excursion.

3-3.3.2.3.1.2 30 Hz FM signals.- The sinusoidal signal which frequency modulates the 9960 Hz FM signal shall be 30 Hz ±0.05 percent. The phase of the 30 Hz FM signal shall not vary by more than 0.01 degree at any phase adjustment (3-3.3.2.3.3.1).

3-3.3.2.3.1.3 Harmonic distortion.- The total harmonic distortion of the 30 Hz FM signal shall be less than 0.5 percent.

3-3.3.2.3.2 FM output.- The following shall be required.

3-3.3.2.3.2.1 FM output level adjustments.- Means shall be provided to allow adjustment of the FM subcarrier signal output level in steps of 0.5 percent amplitude modulation over the range of 20 percent modulation to 40 percent modulation (as indicated on the VOR monitor).

3-3.3.2.3.2.2 FM output level stability.- The output level shall not vary by more than ±0.2 percent for any setting of the output level (3-3.3.2.3.2.1).

3-3.3.2.3.2.3 Hum distortion.- The root sum square of all hum distortion frequencies shall not exceed a value corresponding to 65 dB below the specified minimum output level (3-3.3.2.3.2.1).

3-3.3.2.3.3 30 Hz amplitude modulation (AM) Signal.- The phase of the sinusoidal 30 Hz AM signal shall meet the requirements of the following subparagraphs.

3-3.3.2.3.3.1 30 Hz AM signal phase.- The nominal phase of the sinusoidal 30 Hz AM signal shall be within ±0.05 degrees of the phase of the 30 Hz FM signal (3-3.3.2.3.1.2) at an azimuth setting of 000.0 degrees. The phase difference between the 30 Hz AM signal and the 30 Hz FM signal shall be within ±0.05 degree from nominal azimuth setting for any other phase, 000.1 through 359.9 degrees.

3-3.3.2.3.3.2 30 Hz AM output level adjustment.- Means shall be provided to allow adjustment of the 30 Hz AM signal output level in steps of 0.5 percent modulation, over the range of 20 percent modulation to 40 percent modulation (as indicated on the VOR monitor). Means shall be provided for selection of only the 30 subcarrier shall meet the requirements of the following subparagraphs.

3-3.3.2.3.1.1 FM subcarrier frequency.- The nominal frequency of the FM subcarrier signal shall be 9960 Hz, frequency modulated ±480 (±8 Hz) by a 30 Hz sinusoid. The frequency deviation shall be adjustable to 9960 ±360 Hz through 9960 ±600 Hz, as a minimum, in increments of 10 Hz or less and with stability of ±4 Hz once set. The increasing 9960 frequency represents the positive going 30 Hz excursion.

3-3.3.2.3.1.2 30 Hz FM signals.- The sinusoidal signal which frequency modulates the 9960 Hz FM signal shall be 30 Hz ±0.05 percent. The phase of the 30 Hz FM signal shall not vary by more than 0.01 degree at any phase adjustment (3-3.3.2.3.3.1).

3-3.3.2.3.1.3 Harmonic distortion.- The total harmonic distortion of the 30 Hz FM signal shall be less than 0.5 percent.

3-3.3.2.3.2 FM output.- The following shall be required.

3-3.3.2.3.2.1 FM output level adjustments.- Means shall be provided to allow adjustment of the FM subcarrier signal output level in steps of 0.5 percent amplitude modulation over the range of 20 percent modulation to 40 percent modulation (as indicated on the VOR monitor).

3-3.3.2.3.2.2 FM output level stability.- The output level shall not vary by more than ±0.2 percent for any setting of the output level (3-3.3.2.3.2.1).

3-3.3.2.3.2.3 Hum distortion.- The root sum square of all hum distortion frequencies shall not exceed a value corresponding to 65 dB below the specified minimum output level (3-3.3.2.3.2.1).

3-3.3.2.3.3 30 Hz amplitude modulation (AM) Signal.- The phase of the sinusoidal 30 Hz AM signal shall meet the requirements of the following subparagraphs.

3-3.3.2.3.3.1 30 Hz AM signal phase.- The nominal phase of the sinusoidal 30 Hz AM signal shall be within ±0.05 degrees of the phase of the 30 Hz FM signal (3-3.3.2.3.1.2) at an azimuth setting of 000.0 degrees. The phase difference between the 30 Hz AM signal and the 30 Hz FM signal shall be within ±0.05 degree from nominal azimuth setting for any other phase, 000.1 through 359.9 degrees.

3-3.3.2.3.3.2 30 Hz AM output level adjustment.- Means shall be provided to allow adjustment of the 30 Hz AM signal output level in steps of 0.5 percent modulation, over the range of 20 percent modulation to 40 percent modulation (as indicated on the VOR monitor). Means shall be provided for selection of only the 30

3-3.3.2.4 VOR certification parameters.- The certification parameters listed below shall be automatically verified by means of exercising the VOR test generator or other built-in circuitry as required without interruption of normal operation (other than momentary bypass of the monitor, if required). The exercising of the VOR test generator or other required built-in circuitry or test equipment shall be accomplished through the PMDT or MPS interface.

Service	Certification Parameters	Standards	Operating Tolerance Limits
Coverage	Power Output	Nominal output	At least 75% of nominal output
Azimuth Accuracy	a) Azimuth Alignment	On course at the monitored radial	±1.0 degree from standard
	b) Monitor Azimuth	Course shifts in excess of ±1.0 degree shall cause an alarm	Same as Standard
Course Sensitivity	a) Modulation Level (9960 Hz AM)	30%	28% to 32%
	b) Modulation Level (30 Hz AM)	30%	28% to 32%

3-3.3.2.4 VOR certification parameters.- The certification parameters listed below shall be automatically verified by means of exercising the VOR test generator or other built-in circuitry as required without interruption of normal operation (other than momentary bypass of the monitor, if required). The exercising of the VOR test generator or other required built-in circuitry or test equipment shall be accomplished through the PMDT or MPS interface.

Service	Certification Parameters	Standards	Operating Tolerance Limits
Coverage	Power Output	Nominal output	At least 75% of nominal output
Azimuth Accuracy	a) Azimuth Alignment	On course at the monitored radial	±1.0 degree from standard
	b) Monitor Azimuth	Course shifts in excess of ±1.0 degree shall cause an alarm	Same as Standard
Course Sensitivity	a) Modulation Level (9960 Hz AM)	30%	28% to 32%
	b) Modulation Level (30 Hz AM)	30%	28% to 32%

Service	Certification Parameters	Standards	Operating Tolerance Limits
Coverage	Receiver Sensitivity	-94 dBm	-91 dBm
	Monitor Rcvr/ Sensitivity Alarm	-91 dBm	±1.0 dBm
	Reply Pulse Spacing	12 us (X mode)	±0.2 us
	Monitor Reply Pulse Spacing Alarm	11.2 - 12.8 us	±0.2 us
	Receiver Decoder	11 - 13 us	11 - 13 us
	Peak Power DME	1.0 kw	at least 500w
	Monitor Peak Power Alarm	500 w	±10%
Distance Accuracy	Reply Delay	50 us (49.3 us Mountain Top)	±0.2 us ±0.2 us
	Monitor Reply Delay Alarm	±0.6 us	±0.2 us
	Reply Efficiency	98%	70%
	Count Squitter	1350 ± 50	±100
	Low Alarm Limit	850 ± 50	850 ± 100
	High Alarm Limit	None	None
Identification	Monitor Ident Alarm	Morse Code established at 1350 Hz ±5 Hz	±10 Hz

3-3.3.2.6 Additional tests and measurements.- In addition to the certification parameters listed in 3-3.3.2.5, capability shall be provided to measure and test the following parameters, selectable from the PMDT or MPS interface with the specified adjustment accuracy:

(a) Transponder output duration, rise and decay times (±0.1 us).

(b) Transponder output pulse coding (±0.1 us).

(c) Transponder receiver echo suppression (±0.1 us).

(d) Transponder receiver sensitivity on channel, ± 200 kHz and ± 900 kHz (±1.0 dB).

(e) Transponder dead time (±1.0 us).

(f) Transponder output pulse rate (±0.01% ± count).

(g) Transponder replies to signal generator interrogations (±2%).

(h) Signal generator pulse width, rise and decay time (±0.1 us).

(i) Signal generator interrogation coding (±0.1 us).

(j) Signal generator interrogation rate us (±0.01% ±1 count).

3-3.3.2.7 VOR and DME control.- The control of the VOR transmitter and the DME transponder shall normally be performed by the VOR and DME monitors, respectively, through the FCPU equipment interfaces. When one monitor shows happy (paragraph 1-3.1.10.7) and one shows an alarm condition (paragraph 1-3.1.10.5), the control shall be shifted to the FCPU whereby an integrity verification check shall be made upon the monitor showing happy.

3-3.3.2.7.1 Integrity test.- A software routine shall be provided to test the VOR and DME monitors using the built-in test equipment to determine the integrity of the equipment. This check shall consist of exercising the monitor with the appropriate built-in test equipment through the software routine. If this test shows the happy monitor to be malfunctioning, then the FCPU shall have the functioning monitor do the control of the VOR or DME. The FCPU shall then continuously inform the VOR or DME that only one monitor shall be used for control. When only one monitor (upon failure of one of the dual monitors) is used, then the FCPU shall automatically perform the monitor integrity test periodically through software control.

3-3.3.2.6 Additional tests and measurements.- In addition to the certification parameters listed in 3-3.3.2.5, capability shall be provided to measure and test the following parameters, selectable from the PMDT or MPS interface with the specified adjustment accuracy:

(a) Transponder output duration, rise and decay times (±0.1 us).

(b) Transponder output pulse coding (±0.1 us).

(c) Transponder receiver echo suppression (±0.1 us).

(d) Transponder receiver sensitivity on channel, ± 200 kHz and ± 900 kHz (±1.0 dB).

(e) Transponder dead time (±1.0 us).

(f) Transponder output pulse rate (±0.01% ± count).

(g) Transponder replies to signal generator interrogations (±2%).

(h) Signal generator pulse width, rise and decay time (±0.1 us).

(i) Signal generator interrogation coding (±0.1 us).

(j) Signal generator interrogation rate us (±0.01% ±1 count).

3-3.3.2.7 VOR and DME control.- The control of the VOR transmitter and the DME transponder shall normally be performed by the VOR and DME monitors, respectively, through the FCPU equipment interfaces. When one monitor shows happy (paragraph 1-3.1.10.7) and one shows an alarm condition (paragraph 1-3.1.10.5), the control shall be shifted to the FCPU whereby an integrity verification check shall be made upon the monitor showing happy.

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3-3.3.2.9.1.1 Test oscillator output.- The test oscillator, under PMDT or MPS interface control, shall have the capability to provide a continuously variable output signal from 0 to 100,000 microvolts. The oscillator shall be able to modulate the output signal with a 1000 Hz tone adjustable to any value between 20 and 40 percent. The root mean square (RMS) value of the total distortion of the 1000Hz test tone shall not exceed 3.0 percent.

3-3.3.2.9.1.2 RCO receiver testing.- The FCPU shall include the memory capability to control the remote testing of the following parameters of the main and standby RCO communications receivers.

(a) Status control (on-line or off-line)
(b) Voice frequency output (on-line receiver)
(c) Squelch/AGC (on-line receiver)
(d) Measurement of S+N/N (off-line receiver)

3-3.3.2.9.2 Engine generator testing.- The FCPU shall include the memory capability to provide for remote testing of the following performance checks of the facility engine generator (not to be supplied under this specification).

(a) Remote run exercise
(b) Remote stop exercise
(c) Engine oil pressure
(d) Engine coolant temperature
Fuel storage tank level
(|| Generator output voltage (single phase)
Generator output current
(h) Generator output frequency
(i) Battery charging rate (I)
(j) Battery cranking voltage (E)
(k) Engine starting time (normally less than 15 seconds)

3-3.3.2.9.3 External control relays.- For certain control functions, the actual switching will be accomplished by Government furnished 48 volt DC relays located within or near the equipment or device being controlled. Power for operation of these relays shall be provided by the BCPS (see Part 2). The FCPU shall provide the ground return path for the appropriate relay coil by means of a temporary software latch which shall persist for 180 ms ±20 ms. For design and test purposes, it may be assumed that the relay current will not exceed 40 ma under which conditions the voltage drop across the connecting terminals shall not exceed 4 volts. The FCPU shall have the capability to control at least ten external relays. Programming for this function shall be included in the software development specified in paragraph 1-3.8 herein.

3-3.3.2.10 Environmental parameters.- The following sensors together with all necessary cabling, connectors, terminal boards, enclosures, mounting hardware and installation instructions shall be furnished with each VOR/DME equipment 'as specified below. Measurements from the sensors shall be processed by the FCPU for transmission to the MPS at appropriate times and for output locally via the PMDT interface.

(a) Intrusion detector (2 each)
(b) Smoke detector (2 each)
(c) AC power
(d) Inside temperature (2 each)
(e) Outside temperature

3-3.3.2.10.1 Intrusion detector.- The intrusion detector shall detect the opening of the VOR/DME equipment room shelter door and or the VOR/DME engine generator room shelter door (doors or building not to be furnished under this specification). The building security parameter will be timed on when the detector senses that the door has been open for 0.25 seconds. If a portable terminal is not connected to the PMDT interface and a terminal connected message command received via the terminal connected interface within 5 minutes, the RMS shall indicate that the building security parameter is in alarm and it shall generate a priority alarm message. If the portable terminal is connected and a terminal connected message command is received via the terminal interface within 5 minutes, the building security parameter shall return to normal. If after being connected, the portable terminal is disconnected from the terminal interface, the RMS shall inhibit sensing a building security alarm for a period of 5 minutes prior to resuming normal monitoring of the building security parameter. It shall be possible to arm and disarm (bypass) the intrusion detector through remote commands.

3-3.3.2.10.2 Smoke detector.- The VOR/DME systems shall be furnished with an ionization type smoke detector for the VOR/DME equipment room and a photoelectric type smoke detector for the engine generator room. The ionization type smoke detector shall meet the requirements of and bear the label of Underwriters Laboratories, Inc. Standard 268. The photoelectric type detector shall meet the requirements and bear the label of Underwriters Laboratories, Inc. Standard 217. The RMS shall respond to an alarm indication from either smoke detector by generating a priority smoke detector alarm message.

3-3.3.2.10.3 AC power.- Each VOR/DME system shall be provided with an AC power sensor. The AC power sensor shall detect the presence of suitable AC power applied to the BCPS equipment. The RMS shall respond to a change of the AC power sensor by transmitting the AC power parameter during the next poll. The AC power parameter shall be sensed to be in alarm if the BCPS is operating from the output of the standby battery bank (2-3.3.6.1)

3-3.3.2.10.4 Inside temperature.- Each VOR/DME system shall be furnished with two inside temperature sensors. The temperature sensors shall provide the temperature inside the VOR/DME equipment shelter and inside the engine generator room (neither to be furnished under this specification) to the RMS with a minimum resolution of one degree centigrade. The accuracy over the range of -40 to +50 degrees centigrade shall be ± two degrees centigrade. The RMS shall be programmable for an upper and lower temperature limit and shall transmit an alert message during the next poll if a limit is exceeded.

3-3.3.2.10.5 Outside temperature.- Each VOR/DME system shall be furnished with an outside temperature sensor. The temperature sensor shall provide the outside temperature to the RMS with a minimum resolution of one degree centigrade. The accuracy over the range of -50 to +70 degrees centigrade shall be ± two degrees centigrade. The outside temperature shall be available as an entry on the site data report.

3-3.3.2.11 FCPU monitor and control functions.- In addition to the certification parameters of paragraphs 3-3.3.2.4 and 3-3.3.2.5, the tests and measurements of paragraph 3-3.3.2.6 and the environmental parameters of paragraphs 3-3.3.2.10.1 through 3-3.3.2.10.5, the additional parameters and functions to be monitored and controlled shall be proposed by the contractor and submitted for Government review and approval as part of the Preliminary Design Review to be held in accordance with the contract schedule. The contractor's proposed list shall include, as a minimum, all monitored parameters with normal, alarm and pre-alarm limits, all transmitter/transponder signal characteristics, adjustments and controls, the testing of all monitor alarm parameters, monitor alarm threshold adjustments, monitor bypass controls, equipment transfer and reset and other functions necessary to comply with the intent and requirements Of paragraphs 1-3.3.13 and 3-3.2.15 herein.

3-3.3.3 FCPU communications functions.- The FCPU shall provide the communications functions described in the following subparagraphs.

3-3.3.3.1 Communications with the RSCE site.- The communication between the VOR/ DME facility and the RSCE site is via 4- wire lines (see paragraph 1-3.3.13.3) and the following subparagraphs shall apply. Levels shall be adjustable between -30 dBm through +6 dBm.

3-3.3.3.1.1 Data Transmission.- Data from the FCPU shall be converted for transmission (see paragraph 3-3.3.1.4) over the telephone line along with the communications voice. It shall be possible to remove the data from the voice/data channel and convert it for use at the RSCE site (see Part 9). Hardware shall

3-3.3.2.10.4 Inside temperature.- Each VOR/DME system shall be furnished with two inside temperature sensors. The temperature sensors shall provide the temperature inside the VOR/DME equipment shelter and inside the engine generator room (neither to be furnished under this specification) to the RMS with a minimum resolution of one degree centigrade. The accuracy over the range of -40 to +50 degrees centigrade shall be ± two degrees centigrade. The RMS shall be programmable for an upper and lower temperature limit and shall transmit an alert message during the next poll if a limit is exceeded.

3-3.3.2.10.5 Outside temperature.- Each VOR/DME system shall be furnished with an outside temperature sensor. The temperature sensor shall provide the outside temperature to the RMS with a minimum resolution of one degree centigrade. The accuracy over the range of -50 to +70 degrees centigrade shall be ± two degrees centigrade. The outside temperature shall be available as an entry on the site data report.

3-3.3.2.11 FCPU monitor and control functions.- In addition to the certification parameters of paragraphs 3-3.3.2.4 and 3-3.3.2.5, the tests and measurements of paragraph 3-3.3.2.6 and the environmental parameters of paragraphs 3-3.3.2.10.1 through 3-3.3.2.10.5, the additional parameters and functions to be monitored and controlled shall be proposed by the contractor and submitted for Government review and approval as part of the Preliminary Design Review to be held in accordance with the contract schedule. The contractor's proposed list shall include, as a minimum, all monitored parameters with normal, alarm and pre-alarm limits, all transmitter/transponder signal characteristics, adjustments and controls, the testing of all monitor alarm parameters, monitor alarm threshold adjustments, monitor bypass controls, equipment transfer and reset and other functions necessary to comply with the intent and requirements Of paragraphs 1-3.3.13 and 3-3.2.15 herein.

3-3.3.3 FCPU communications functions.- The FCPU shall provide the communications functions described in the following subparagraphs.

3-3.3.3.1 Communications with the RSCE site.- The communication between the VOR/ DME facility and the RSCE site is via 4- wire lines (see paragraph 1-3.3.13.3) and the following subparagraphs shall apply. Levels shall be adjustable between -30 dBm through +6 dBm.

3-3.3.3.1.1 Data Transmission.- Data from the FCPU shall be converted for transmission (see paragraph 3-3.3.1.4) over the telephone line along with the communications voice. It shall be possible to remove the data from the voice/data channel and convert it for use at the RSCE site (see Part 9). Hardware shall a minimum of 2 hours. Batteries may be used to provide the 2 hour nonvolatility.

3-3.3.4.8 Alternative Voice Input.- The equipment shall include provisions to accept an alternate voice input from Government furnished equipment that will be used to con*inuously modulate the voice channel of the VOR transmitter when it is not being modulated by voice on the dedicated telephone line. If the Government elects to use the alternate voice input, it shall be used in lieu of the voice identification of paragraph 3-3.3.4 and the voice identification shall be disabled with no adverse effects. The push to talk (PTT) signal of paragraph 9-3.2.1.2 shall remove the alternate voice input from the voice channel of the VOR transmitter and connect the dedicated line in its place. Application of the PTT signal shall additionally cause a 600 ohm load to be simultaneously placed across the input terminals of the alternate voice input line to preclude open circuit damage to the equipment connected to the line. The line shall be made available, by the Government, to a contractor furnished terminal board within the cabinets containing the FCPU.

3-3.4 Software

To perform the functions required by section 3-3.3 above, FCPU software components shall, as a minimum, be provided as follows.

(a) Remote Monitoring System (RMS) software (sections 3-3.4.1 through 3-3.4.4)
(b) Operating software (3-3.4.5)
(c) Fault diagnosis software (3-3.4.6)
(d) Installation and checkout software (3-3.4.7)
(e) Utility software (3-3.4.8)

The most detailed requirements presented to the contractor by the FAA are in the RMS software; for this reason the following sections discuss these RMS requirements in terms of functional requirements, required processing of message sequences, allowed message structure, FCPU/MPS communications interface requirements, and specF?ic VOR/DME RMS requirements. Software requirements found elsewhere in the FCPU specification are then allocated to the remaining software components.

3-3.4.1 RMS software

The RMS software shall implement the required software for data collection, alarm detection, message processing, and the communications interface with the Maintenace Processing System (MPS), as described in NAS-MD-790, NAS-MD-793, and 3-3.2.13.

The RMS software shall provide the capability to perform data collection of all available data (see Parts 1 through 7 of the specification) from the VOR, DME, environmental, and communications equipment. This data shall be organized into logical units: a logical unit is defined as a collection of parameters by physically segregated hardware, common functions, or conditions that have functional and/or physical commonality. Logical units are used to group all reportable parameters, including status and conditions.

The VOR/DME RMS software shall use both periodic scanning and software or hardware interrupt techniques to detect and handle faults, alarms, or status changes from any monitored parameter. The RMS software shall also provide the capability of generating messages to be used by the MPS for determining alarms from the facility.

The RMS software provides operator access and control over the VOR/DME equipment installation, through either a Maintenance Data Terminal (MDT) attached to the MPS, or the Portable Maintenance Data Terminal (PMDT) (3-3.2.16) attached to the FCPU. The RMS software shall support two distinct modes of operation, involving on-site security, and MPS security, communications and control. During normal operation, the RMS shall be in remote control mode, in which all control is provided by MPS, and the RMS provides pass-through access from PMDT to MPS. During authorized on-site maintenance the RMS shall be in local control mode in which the technician at the PMDT is in control. The RMS software shall enter remote control mode on initialization if MPS communications are active, and local control mode otherwise. The authorized maintenance technician may request the MPS that the remote control mode VOR/DME RMS enter local control mode. If MPS communications fails during remote control mode, the RMS shall enter local control mode. If MPS communications are reestablished during local control mode, or if the technician relinquishes local control, the VOR/DME RMS shall reenter remote control mode after notification to the technician.

VOR/DME security functions shall consist of two primary components: physical security and process security. The physical security component shall handle the monitoring and reporting of access to VOR/DME facilities and the detection and reporting of smoke within these facilities. The process security component shall control access to and use of the RMM data bases and the other RMM functions such as remote certification, and remote control and adjustment. The RMS will be involved in process security because of its role in providing on-site security control, and in the interfacing of the PMDT at the VOR/DME site with the MPS.

The RMS system administration function shall consist of two primary components: system initialization and system performance. The system initialization component involves the execution of activities associated with the start-up of a computer within the RMS after a planned shutdown or an unplanned communications equipment. This data shall be organized into logical units: a logical unit is defined as a collection of parameters by physically segregated hardware, common functions, or conditions that have functional and/or physical commonality. Logical units are used to group all reportable parameters, including status and conditions.

The **VOR/DME RMS** software shall use both periodic scanning and software or hardware interrupt techniques to detect and handle faults, alarms, or status changes from any monitored parameter. The **RMS** software shall also provide the capability of generating messages to be used by the **MPS** for determining alarms from the facility.

The **RMS** software provides operator access and control over the **VOR/DME** equipment installation, through either a Maintenance Data Terminal (MDT) attached to the **MPS**, or the Portable Maintenance Data Terminal **(PMDT) (3-3.2.16)** attached to the **FCPU**. The **RMS** software shall support two distinct modes of operation, involving on-site security, and **MPS** security, communications and control. During normal operation, the **RMS** shall be in remote control mode, in which all control is provided by **MPS**, and the **RMS** provides pass-through access from **PMDT** to **MPS**. During authorized on-site maintenance the **RMS** shall be in local control mode in which the technician at the **PMDT** is in control. The **RMS** software shall enter remote control mode on initialization if **MPS** communications are active, and local control mode otherwise. The authorized maintenance technician may request the **MPS** that the remote control mode **VOR/DME RMS** enter local control mode. If **MPS** communications fails during remote control mode, the **RMS** shall enter local control mode. If **MPS** communications are reestablished during local control mode, or if the technician relinquishes local control, the **VOR/DME RMS** shall reenter remote control mode after notification to the technician.

VOR/DME security functions shall consist of two primary components: physical security and process security. The physical security component shall handle the monitoring and reporting of access to **VOR/DME** facilities and the detection and reporting of smoke within these facilities. The process security component shall control access to and use of the **RMM** data bases and the other **RMM** functions such as remote certification, and remote control and adjustment. The **RMS** will be involved in process security because of its role in providing on-site security control, and in the interfacing of the **PMDT** at the **VOR/DME** site with the **MPS**.

The **RMS** system administration function shall consist of two primary components: system initialization and system performance. The system initialization component involves the execution of activities associated with the start-up of a computer within the **RMS** after a planned shutdown or an unplanned

The RMS shall also contain the capability for collecting self-test and monitoring information on the status, performance, and use of its own hardware and software elements. This data shall provide the means for evaluating the performance of the RMS related hardware and software, as opposed to the equipment being monitored by the RMS.

(b) Retrieval of equipment data by RMS

The collection of equipment and RMS parameter data shall be done automatically by the RMS on a regular basis and with no need for human intervention. The VOR/DME equipment RMS shall sense such parameters no less than once every five seconds (ref. 3-3.3.1.8). The collection of data at the RMS level, for normal equipment monitoring and alarm purposes, shall be performed without the need for a command from an MPS or PMDT connected to the RMS, and at pre-defined intervals. Each critical parameter shall be checked for an alarm condition at least once during the interval between the receipt of consecutive polls from the MPS. The VOR/DME RMS polling interval shall be a site adaptable parameter set by the MPS so as to allow the RMS to detect and present alarms and state changes from all designated logical units within an average time of 10 seconds and a maximum time of 60 seconds.

The data acquisition process shall not interfere with the normal operation of the equipment being monitored. Passive or non invasive data collection techniques, hardware, and software, shall be used to the maximum extent possible. A failure of any of the data retrieval hardware or software shall not affect the normal operation of the equipment. The data acquisition process shall be performed in such a manner that it shall not interfere with the execution of any of the other RMS functions.

(c) Data conditioning

Data collected by an RMS's sensors shall be conditioned immediately after being collected. Conditioning shall include the conversion of analog outputs from sensors to an equivalent digital form, any necessary scaling of sensor data, any necessary filtering, and any other digital preprocessing required to put the data in a form suitable for processing and storage at the RMS.

3-3.4.1.1.2 Data processing.- The VOR/DME RMS shall perform a number of operations on the data it collects. Data processing required of the VOR/DME RMS shall include, but not necessarily be limited to data comparisons, storage and updating, retrieval, and formatting into messages for transmission up-line.

3-3.4.1.1.2.1 Data comparisons.- The VOR/DME RMS shall have the necessary algorithms and hardware for comparing parameter values collected by the RMS with a set, or sets, of threshold values. These comparisons shall be used to determine failure conditions, change of state conditions, the VOR/DME equipment's response to remote control and adjustment or initialization commands, and to support the remote diagnostic function.

(a) Alarm determination

Out-of-tolerance conditions and failures of VOR/DME equipment shall be identified through a comparison of the equipment parameter values obtained by the RMS sensors against their respective operating threshold values. For each alarm related equipment parameter, which has other than an on/off state, a separate set of threshold values shall be stored in the RMS's memory for determining hard alarm and soft alarm conditions. Soft alarm threshold values shall be remotely changeable. All threshold values shall be stored in digital form.

After collecting an equipment's parameter values and performing any necessary data conditioning, the RMS shall automatically retrieve the alarm threshold values for that parameter and compare them with the collected value. The RMS shall establish, through this comparison, whether or not the parameter is within required operating limits: within required limits, but outside a desired operating range (an indication of a soft alarm): or outside required operating limits (an indication of a hard alarm).

An alarm remains active until the parameter is again within threshold values (returns to normal). Only one alarm shall be generated for each occurence, unless a soft alarm becomes hard or returns to normal. An alarm state shall not be established on the basis of only one comparison: filtering, and/or averaging shall be performed depending on the equipment and parameter. Therefore, for some parameters, several comparisons of the output from a sensor may be performed before an alarm state can be declared. This requirement is intended to minimize the declaration of alarms due to transient conditions.

(b) Return to normal determination

Return to normal comparison shall be performed by the RMS as part of its data comparison activities. This comparison shall be performed to determine if a parameter previously in an alarm condition is again within threshold values for several comparisons, using a method corresponding to those used for alarm determination for the parameter. This determination shall cause generation of a Return-to-Normal message for the parameter as required by NAS-MD-790.

(c) Change of state determination

Change of state comparison shall be performed by the RMS as part of its data comparison activities. This comparison shall be performed to determine if the VOR/DME equipment, or one of its components, has changed to another state (for example, from an operational state to a failed state, or from a failed state to a normal state). The RMS shall be capable of maintaining a record of the state of each of the monitored parameters for at least three interrogation cycles. The retrieval and comparison of this state data shall be performed as part of each cycle in the parameter retrieval and comparison process.

3.3.4.1.1.2.2 Data storage, retrieval and updating.

(a) Data storage

The RMS shall have sufficient storage capacity to store, as a minimum, the following data:

1. Alarm Threshold Values.

Sufficient threshold data shall be stored at the RMS to determine two possible alarm conditions for each of the critical parameters being monitored: out of tolerance conditions (hard alarms) and conditions indicative of an impending failure (soft alarms). It shall be possible to change the RMS's threshold values from the MPS or from a PDMT in local mode.

2. Parameter State Values.

Storage capacity shall be provided for the storage of data that describes the state of each critical parameter, i.e., normal/operational or alarm.

3. Remote Control and Adjustment Command Codes.

The RMS shall be capable of storing the information needed to decode the remote control and adjustment commands it is required to respond to. Remote control and adjustment capabilities for the RMS, and their associated command codes shall be defined by the contractor and shall conform with the format presented in NAS-MD-790.

4. Initialization Tables.

The RMS shall be capable of storing the initialization information, needed to initialize the RMS, in changeable, non volatile memory. Local site changes to this information may be down-loaded from an MPS or PMDT (maximum 512 bytes) as described in NAS-MD-793.

5. Equipment and RMS Parameter Values.

Change of state comparison shall be performed by the RMS as part of its data comparison activities. This comparison shall be performed to determine if the VOR/DME equipment, or one of its components, has changed to another state (for example, from an operational state to a failed state, or from a failed state to a normal state). The RMS shall be capable of maintaining a record of the state of each of the monitored parameters for at least three interrogation cycles. The retrieval and comparison of this state data shall be performed as part of each cycle in the parameter retrieval and comparison process.

3-3.4.1.1.2.2 Data storage, retrieval and updating.

(a) Data storage

The RMS shall have sufficient storage capacity to store, as a minimum, the following data:

1. Alarm Threshold Values.

Sufficient threshold data shall be stored at the RMS to determine two possible alarm conditions for each of the critical parameters being monitored: out of tolerance conditions (hard alarms) and conditions indicative of an impending failure (soft alarms). It shall be possible to change the RMS's threshold values from the MPS or from a PDMT in local mode.

2. Parameter State Values.

Storage capacity shall be provided for the storage of data that describes the state of each critical parameter, i.e., normal/operational or alarm.

3. Remote Control and Adjustment Command Codes.

The RMS shall be capable of storing the information needed to decode the remote control and adjustment commands it is required to respond to. Remote control and adjustment capabilities for the RMS, and their associated command codes shall be defined by the contractor and shall conform with the format presented in NAS-MD-790.

4. Initialization Tables.

The RMS shall be capable of storing the initialization information, needed to initialize the RMS, in changeable, non volatile memory. Local site changes to this information may be down-loaded from an MPS or PMDT (maximum 512 bytes) as described in NAS-MD-793.

5. Equipment and RMS Parameter Values.

communications between RMS and MPS. The data shall be stored until communications is reestablished, and then sent to the MPS. At a minimum, storage capacity for data from ten alarms shall be available.

(b) Data retrieval

Equipment and RMS parameter values collected and stored by the RMS, their associated hard and soft alarm threshold values certification parameter values, and certification threshold values shall be retrievable through the use of requests issued to the RMS through the MPS, and through commands entered from a PMDT in local mode. It shall be possible to retrieve equipment performance and certification related data from the RMS in the following ways:

1. In Total. It shall be possible to retrieve and transmit up-line, all of the RMS's monitored equipment parameter values at one time. This shall be accomplishable through the use of a single NAS-MD-790 Scheduled Poll request.

2. In Sub-Groups or Logical Units. The required logical units of related critical VOR/DME equipment parameters are identified in paragraph 3-3.4.4.10. The data for these logical units shall be stored in such a way that the data for the different logical units can be retrieved and transmitted up-line separately. This retrieval shall be accomplished through the use of a single request from the MPS, and through the use of a single command from a PMDT in local mode.

   Four logical units are required in every RMS: RMS master, terminal, environmental, and communications logical units.

(c) Data updating

Equipment and RMS parameter values and status data being stored at the RMS shall be updated on a frequent and regular basis. The updating process shall be performed automatically without a need for issuing any commands from the MPS or a PMDT in local mode. After new equipment performance data is collected and processed, it shall be written over the data collected and stored during the previous data acquisition cycle. Only the most current equipment performance data shall be stored at the RMS for transmission in response to requests for data.

3-3.4.1.1.2.3 Message generation.- The VOR/DME RMS shall be capable of generating a series of reports and messages in response to: (1) requests for data, (2) remote control and adjustment commands, (3) initialization commands, and (4) the identification of alarms or state changes by the RMS.

"Result" and "Response" messages shall be generated automatically by an RMS, without a need for secondary commands. For example, a "Control Result Message" shall be generated by an RMS as part of its response to the receipt and execution of a Control Command. It shall not be necessary for a system user or MPS to issue a command to the RMS to generate and transmit the "Control Result Message" after issuing the subject Control Command.

Time stamping of RMS Messages shall be required. Message formats shall include timestamp fields, and the RMS shall automatically perform the time stamping based on the value of the FCPU real-time clock (described in paragraph 3-3.3.1.9). The RMS shall also be capable of receiving and interpreting a time synchronization Equipment Control Command message from the MPS, addressed to the RMS Clock logical unit, that causes adjustment of the FCPU real-time clock (as required in 3-3.4.4.10 herein). It should be noted that the time received from the MPS will be approximate, because of delays associated with the transmission of the time synchronization command from MPS to RMS.

Partial descriptions of the formats for these messages are presented in NAS-MD-790. Detailed descriptions are to be provided in the contractor-prepared VOR/DME-MPS ICD (see paragraph 3-3.3.1.13).

(a) Alarm Messages

Alarm states shall be described in the ICD provided by the contractor. An alarm message (either an Alarm State Report or an Alarm Parameter Report) shall not be generated each time an alarm state is determined (as described in 3-3.4.1.1.1(a)) for a particular equipment parameter: only one alarm state message shall be generated per alarm occurrence as determined in multiple data acquisition cycles. If an RMS is in the local control mode when an alarm condition is identified, no alarm message shall be generated by the RMS for transmission up-line to the MPS.

(b) Return-to-Normal Messages

Similarly, a Return-to-Normal message shall be generated when a parameter previously in an alarm state is determined to be within limits in multiple data acquisition cycles.

(c) Control state change related messages

When a control state has been changed by the MPS, a system user or the equipment RMS (e.g., automatic switch over from primary to back-up unit), the appropriate control state change message shall be automatically generated by the RMS.

3-3.4.1.1.2.4 Trend data storage

The VOR/DME RMS software shall have the capability of programming for automatic storage at 1 to 72 hour intervals (adjustable in 1/2 hour steps) of all parameter data selectable for trend analysis.

3-3.4.1.1.2.5 Command processing.- A primary function for the RMS shall be responding to commands from the MPS. This includes actions performed in response to a failure, as well as actions performed when no failure condition is declared. Examples of this capability include initializing the subsystem, and the adjusting of equipment control parameters as operational demands on the equipment change.

(a) Equipment remote control, adjustment, diagnostic and initialization requirements

Remote control, adjustment, diagnostic, and initialization capabilities and commands shall be defined by the contractor and shall be documented in the contractor-prepared ICD. The RMS must be capable of receiving and recognizing valid commands, controlling the execution of those commands, determining the equipment's state after the execution of the command, and generating the appropriate message for reporting the results to the user who issued the command.

(b) Command acceptance and verification

The RMS shall be designed to accept commands formatted in accordance with the command message format presented in NAS-MD-790.

Upon receiving a command message, the RMS shall verify that the command is a valid command. This shall be accomplished through the use of the command code transmitted as part of the command message. If the command is found to be an invalid command, the RMS shall generate the appropriate Command Reject Message to report that the command was not executed.

(c) Command execution

If a command received by the RMS is found to be a valid command, the RMS shall select and execute the appropriate process control algorithm or change the desired equipment parameter value. Execution of the command shall be accomplished without a need for secondary commands or human intervention. If the RMS is in the local control mode when a command comes from the MPS, the command shall not be executed and a Command Reject message shall be formatted for up-line transmission.

3-3.4.1.1.2.4 Trend data storage

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Remote control, adjustment, diagnostic, and initialization capabilities and commands shall be defined by the contractor and shall be documented in the contractor-prepared ICD. The RMS must be capable of receiving and recognizing valid commands, controlling the execution of those commands, determining the equipment's state after the execution of the command, and generating the appropriate message for reporting the results to the user who issued the command.

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acquisition of facility and RMS performance data and alarms through on-site control.

(2) System performance

The VOR/DME RMS shall be capable of monitoring its own performance and reporting instances of failures or unacceptable performance of its hardware and software components. The RMS's design shall include hardware and software monitors for the automatic monitoring and recording of information on the status and use of its own hardware and software elements. Alarms and status information gathered under this capability as a Logical Unit shall be transmitted to the MPS or PMDT connected to it in the same way as facility related alarms and status information.

3-3.4.2 RMS process descriptions

3-3.4.2.1 Monitoring function

3-3.4.2.1.1 Objective.- The monitoring function permits the implementation of all the other RMMS operational capabilities which require the use of either real-time or historical data for assessing the performance of remote equipment.

3-3.4.2.1.2 Process description.- Monitoring the performance of VOR/DME equipment at remote facilities will be possible from a centralized location (the remote control mode) or at the facility site (the local control mode). Under the remote control mode, the capabilities of the RMS will be controlled by the MPS only. When the RMS is being operated in the remote control mode, the MPS will oversee and control the overall monitoring process, controlling access to the monitoring requests. The RMS in the equipment will still, however, control and perform the actual acquisition of the VOR/DME equipment's performance data.

When in the local control mode, the RMS's capabilities will be controlled by an authorized user at the RMS site. Monitoring of the performance of the VOR/DME equipment, under the local control mode, will use a PMDT connected directly through the FCPU-PMDT interface.

In either remote or local control mode, it will be possible to monitor equipment on both a demand basis and automatic basis. On-demand monitoring will provide a capability for retrieving the performance data from the VOR/DME equipment at some unscheduled time, and for some user specified period of time. Automatic monitoring will provide a capability for the retrieval of VOR/DME equipment performance data, which must be acquired on a regular and frequent basis, without human involvement, using continuous polling of alarm, state change, and return-to-normal messages as described in NAS-MD-790. The major difference between the two monitoring modes will be in the way the data retrieval process will be initiated and in the way the requested information will be disseminated. The following discussion describes processing for remote control mode: in local control mode, messages pass directly between the **PMDT** and the **RMS**.

<u>3.3.4.2.1.2.1 Demand **monitoring**.</u>- The sequence of events and the subfunctions associated with demand monitoring, when an authorized user, working at an MDT, or the **PMDT** attached to the **VOR/DME FCPU**, wants to monitor the performance of a specific **VOR/DME** equipment site from the **MPS**, are presented in this subsection.

1. **<u>MPS</u>.** The functions that the **MPS** will have to perform to get an **RMS** to respond to a data request are described below. They will, for the most part, be the same functions performed by the **MPS** in support of the automatic monitoring function.

   a. <u>Retrieve Data Request Message</u>. At predetermined intervals, the **MPS** will poll the MDT, or **PMDT** via **VOR/DME RMS**, to retrieve any data or message waiting for transmission. The data request message will be transmitted up-line to the **MPS** in response to such a poll.

   b. <u>Identify Data</u>. Upon being received by the **MPS**, the message function code transmitted with the message will be decoded to determine the message's type, content, and priority. Function code identification tables will be maintained in the **MPS's** data base for this purpose.

   c. <u>Interpret Data</u>. Prefixes, such as a message function code and address codes, transmitted with the data request message will be decoded to determine what processing is to be performed by the **MPS**.

   d. <u>Security Check</u>. Before any action is taken by the **MPS** a security check will be made to determine if the individual requesting the data is authorized to receive it. If the results of this check indicate that the requester is not authorized to receive the requested data, a message refusing the request will be generated by the **MPS** and routed to the data requester's terminal for display. The data request session would be terminated by the **MPS** after the refusal message is transmitted down-line to the requester's terminal. Information on the unauthorized request for monitored data will also be entered into a security file, as part of the session close-out process.

will be initiated and in the way the requested information will be disseminated. The following discussion describes processing for remote control mode: in local control mode, messages pass directly between the PMDT and the RMS.

3-3.4.2.1.2.1 Demand monitoring.- The sequence of events and the subfunctions associated with demand monitoring, when an authorized user, working at an MDT, or the PMDT attached to the VOR/DME FCPU, wants to monitor the performance of a specific VOR/DME equipment site from the MPS, are presented in this subsection.

1. MPS. The functions that the MPS will have to perform to get an RMS to respond to a data request are described below. They will, for the most part, be the same functions performed by the MPS in support of the automatic monitoring function.

   a. Retrieve Data Request Message. At predetermined intervals, the MPS will poll the MDT, or PMDT via VOR/DME RMS, to retrieve any data or message waiting for transmission. The data request message will be transmitted up-line to the MPS in response to such a poll.

   b. Identify Data. Upon being received by the MPS, the message function code transmitted with the message will be decoded to determine the message's type, content, and priority. Function code identification tables will be maintained in the MPS's data base for this purpose.

   c. Interpret Data. Prefixes, such as a message function code and address codes, transmitted with the data request message will be decoded to determine what processing is to be performed by the MPS.

   d. Security Check. Before any action is taken by the MPS a security check will be made to determine if the individual requesting the data is authorized to receive it. If the results of this check indicate that the requester is not authorized to receive the requested data, a message refusing the request will be generated by the MPS and routed to the data requester's terminal for display. The data request session would be terminated by the MPS after the refusal message is transmitted down-line to the requester's terminal. Information on the unauthorized request for monitored data will also be entered into a security file, as part of the session close-out process.

be formatted into the appropriate Parameter Response message. Parameter values would have already been placed in the required order and designated field. Formatting at this point would involve adding the necessary communication control characters, message function code, and address codes. An address field **stored** in the **RMS's** data base will be used to determine the correct address information to add to the Parameter Response message.

<u>**3-3.4.2.1.2.2** Automatic **monitoring.-**</u> The **RMMS** will provide for the retrieval of equipment data from **RMSs** without any human intervention, through the use of an automatic monitoring capability. Automatic monitoring will differ from demand monitoring in the way the process is initiated and in the way the retrieved data is disseminated. Data collection and processing requirements for the **RMS** will be the same under automatic monitoring as those required of the **RMS** under demand monitoring. **Processing** requirements for the **MPS** under automatic monitoring will be slightly different than those under demand monitoring.

Under automatic monitoring, continuous polls (low-level protocol polls as described in **NAS-MD-790**) for retrieving equipment performance data from a particular **RMS** will be generated automatically by the **MPS.** A schedule for retrieving data from equipment assigned to a particular **MPS** will be specified in site adaptable tables maintained in the **MPS's** data base. These tables will be scanned on a regular basis to determine if a Parameter Request message has to be generated in order to retrieve any equipment performance data. Parameter Request messages generated through this process will be routed to the target **RMS** in the same manner described previously. When the response to the Parameter Request message is received by the **MPS,** the data will be processed for storage in the **MPS's** data base.

<u>**3-3.4.2.2** Alarm function</u>

<u>**3-3.4.2.2.1 Objective.-**</u> The primary objective behind implementing the alarm capability is to reduce the amount of time that passes between when an equipment failure, out of tolerance, or state change condition occurs, and when the appropriate personnel are notified. This capability will also provide personnel responsible for the equipment with an indication of what component or equipment subsystem caused the alarm, or of the severity of the problem, by providing values for the monitored parameter that triggered the alarm, state change notice, or return to normal message.

3-3.4.2.2 2 Process description.- The automatic alarm detection and notification function will provide immediate notification to the organizational element having maintenance responsibility of the VOR/DME equipment. Alarm recognition processing will be performed automatically as equipment/facility problems or failures occur. Unlike other functions, such as the monitoring function of the remote control and adjustment function, the alarm function will be driven by actions that occur at the VOR/DME sites.

Equipment parameter values will be collected on a regular and frequent basis by the RMS through sensors. The RMS will compare the collected parameter values with predefined tolerance limits, or threshold values, to determine if an alarm condition exists. If an alarm condition is detected, the RMS will generate the appropriate alarm message and then store it until it can be retrieved by the MPS.

The MPS will be responsible for retrieving alarm messages by polling the RMS. The sequence of events and the subfunctions associated with automatic alarm detection and notification are presented below.

1. RMS. The functions required of the RMS in order to detect failure, state change, or return to normal conditions and report such occurrences are presented below.

a. Get Discrete and Analog Data. The acquisition of alarm related system performance data shall be performed by a data acquisition subsystem of the RMS. It will provide the interface between the RMS and the actual equipment. It will consist of sensors and stimulators which will be embedded in the VOR/DME equipment being monitored.

The sensors will acquire both analog signals/data (e.g., AC voltage, AC current, line frequency, etc.) and discrete signals/data (e.g., contact closures or voltages indicating the "ON" or "OFF" status of intrusion alarms, engine generators, etc.). Stimulators will be required for equipment such as monitors or transmitters, to provide a controlled and known signal for use in checking their performance. The data acquisition process will be automatic and continuous, and will not interfere with the normal operation of the equipment being monitored.

b. Condition data. Conditioning of analog data acquired from the sensors may be required before comparisons can be made with the respective alarm tolerance limits. Some conditioning and data conversion may be automatically performed at the sensor level. The remainder will be performed by the FCPU.

c. Retrieve Tolerance Limits Data. Out-of-tolerance conditions or state changes shall be determined through a comparison of the parameter values obtained by the sensors against their respective tolerance limits. Tolerance and threshold data will be stored in the RMS in some form of changeable, non volatile memory. Mechanical storage devices shall not be used.

Sufficient tolerance limit data shall be stored at the RMS to determine two possible alarm conditions: actual failures and the detection of smoke or physical intrusion at the facility (hard alarms): and conditions indicative of an impending failure (soft alarms). Hard alarm threshold values shall be adjustable up to fixed limits. Hard alarm limits will be absolute and not changed on a frequent basis. Soft alarm conditions will be determined through the use of a separate set of threshold values. These values will be chosen such that a soft alarm will be generated before a failure occurs. They will be adjustable up to the hard alarm threshold values.

As part of the alarm checking process, the RMS must retrieve the appropriate threshold values from their respective data base files. This retrieval activity will be performed automatically.

In order to establish whether or not an equipment status change has occurred, the RMS must also retrieve status related parameter value data for the previous interrogation cycle. This historical data will be stored in the RMS's data base for retrieval at this time.

d. Compare Data. The threshold values retrieved will be compared with the actual parameter values obtained from the sensors. This comparison will establish whether or not an alarm condition exists, and if so, what kind of alarm. A state comparison will also be performed as part of the data comparison activity. The current status related parameter values will be compared against the last set of values for those parameters to determine if there was a state change since the previous interrogation cycle. The state comparison will establish if the equipment has gone from a non alarm, operational state to an alarm state or vice versa.

e. Generate Alarm/Status Change Message.

If a parameter goes from a non-alarm state to a soft alarm state, an alert message shall be generated. If a parameter goes from either a non-alarm or a soft alarm state to a hard alarm state, an alarm message shall be generated. If a parameter goes from an alarm state to a non-alarm state, a "Return-to-Normal" message shall be generated.

c. <u>Retrieve Tolerance Limits Data</u>. Out-of-tolerance conditions or state changes shall be determined through a comparison of the parameter values obtained by the sensors against their respective tolerance limits. Tolerance and threshold data will be stored in the RMS in some form of changeable, non volatile memory. Mechanical storage devices shall not be used.

Sufficient tolerance limit data shall be stored at the RMS to determine two possible alarm conditions: actual failures and the detection of smoke or physical intrusion at the facility (hard alarms): and conditions indicative of an impending failure (soft alarms). Hard alarm threshold values shall be adjustable up to fixed limits. Hard alarm limits will be absolute and not changed on a frequent basis. Soft alarm conditions will be determined through the use of a separate set of threshold values. These values will be chosen such that a soft alarm will be generated before a failure occurs. They will be adjustable up to the hard alarm threshold values.

As part of the alarm checking process, the RMS must retrieve the appropriate threshold values from their respective data base files. This retrieval activity will be performed automatically.

In order to establish whether or not an equipment status change has occurred, the RMS must also retrieve status related parameter value data for the previous interrogation cycle. This historical data will be stored in the RMS's data base for retrieval at this time.

d. <u>Compare Data</u>. The threshold values retrieved will be compared with the actual parameter values obtained from the sensors. This comparison will establish whether or not an alarm condition exists, and if so, what kind of alarm. A state comparison will also be performed as part of the data comparison activity. The current status related parameter values will be compared against the last set of values for those parameters to determine if there was a state change since the previous interrogation cycle. The state comparison will establish if the equipment has gone from a non alarm, operational state to an alarm state or vice versa.

e. <u>Generate Alarm/Status Change Message</u>.

If a parameter goes from a non-alarm state to a soft alarm state, an alert message shall be generated. If a parameter goes from either a non-alarm or a soft alarm state to a hard alarm state, an alarm message shall be generated. If a parameter goes from an alarm state to a non-alarm state, a "Return-to-Normal" message shall be generated.

requirements. The receipt of a Certification Command shall be established at this point. The response required of the RMS shall be to transmit all of its current certification parameter values.

3. Certification Data Retrieval.- Once the RMS receives a Certification Command message, it shall begin collecting the requested data from the RMS sensors. In some cases, off-line tests may have to be performed to acquire the data. The certification data collected by the RMS sensors shall be conditioned immediately after being collected and then grouped in a logical unit and stored.

4. Format Data. Before the certification data stored by the RMS are transmitted to the MPS, they shall be formatted into a Certification Parameter Response message. The Certification Parameter Response message shall have the same form as a Site Data Report defined in NAS-MD-790. Parameter values shall have already been placed in the required order and designated fields. Formatting at this point shall involve adding the necessary communication control characters, message function code, and address codes. An address file stored in the RMS's data base shall be used to determine the appropriate address information to add to the response message.

3-3.4.2.3.2.2 Automated certification.- The RMMS provides for the automated retrieval of equipment certification data from the VOR/DME RMS without any human intervention. This capability is referred to as automated certification. Automated certification differs from demand certification primarily in the way the process is initiated and controlled. The automated certification process will be controlled completely by the MPS, as opposed to an authorized person. Functions and processes required of the VOR/DME RMS will be the same under the automated certification mode as under the demand certification mode.

3-3.4.2.4 Remote control and adjustment function

3-3.4.2.4.1 Objective.- The primary objective to be achieved through implementation of the remote control and adjustment capability is the ability to perform equipment restoration activities and/or equipment adjustments to correct some equipment out-of-tolerance conditions from the MPS.

3-3.4.2.4.2 Process description.- The remote control and adjustment capability will permit system users at the MPS to power equipment up or down, and adjust equipment to correct out-of-tolerance parameters without having to visit the site.

The functions that the RMS shall perform after it receives a remote control or adjustment command are described in detail below.

1. Receive Command. When a complete control or adjustment command has been received by the RMS, the command address data shall be examined by the RMS to determine whether it is to be retained and processed by the RMS or transmitted to the PMDT. This examination will establish that the command has reached its intended device destination and that some response to or processing of the command just received is required.

2. Interpret Command. The message function code transmitted as part of the command shall be interpreted next to determine what type of message has been received by the RMS, and, therefore, what kind of response is required. This decoding activity will establish that a control or adjustment command has been received, as opposed to some other type of message. Message function code definitions stored in the RMS's memory shall provide a means for decoding the message function code.

3. Execute Command. A command code and logical unit address will be transmitted as part of the command message. The RMS shall decode the command code to determine what control or adjustment action has to be performed. The logical unit address will tell the RMS to which logical unit the command has to be directed. The command code will instruct the RMS to take one of several actions:

- Reset and restart operations (i.e., clear all monitored data samples, clear all alarm information, unlock any disabled automatic switch over functions, etc.):
- Perform all start up/recovery actions, such as the actions described above, and all of the actions normally performed during initial power-on:
- Turn equipment off or on:
- Change equipment parameters; or
- Change threshold levels/values.

Remote control and adjustment capabilities and commands for the VOR/DME RMS shall be documented in the contractor-prepared VOR/DME-MPS ICD as specified in paragraph 3-3.3.1.13.

The RMS shall perform the required command action by selecting and executing the appropriate process control algorithm or

The functions that the RMS shall perform after it receives a remote control or adjustment command are described in detail below.

1. Receive Command. When a complete control or adjustment command has been received by the RMS, the command address data shall be examined by the RMS to determine whether it is to be retained and processed by the RMS or transmitted to the PMDT. This examination will establish that the command has reached its intended device destination and that some response to or processing of the command just received is required.

2. Interpret Command. The message function code transmitted as part of the command shall be interpreted next to determine what type of message has been received by the RMS, and, therefore, what kind of response is required. This decoding activity will establish that a control or adjustment command has been received, as opposed to some other type of message. Message function code definitions stored in the RMS's memory shall provide a means for decoding the message function code.

3. Execute Command. A command code and logical unit address will be transmitted as part of the command message. The RMS shall decode the command code to determine what control or adjustment action has to be performed. The logical unit address will tell the RMS to which logical unit the command has to be directed. The command code will instruct the RMS to take one of several actions:

- o Reset and restart operations (i.e., clear all monitored data samples, clear all alarm information, unlock any disabled automatic switch over functions, etc.):
- o Perform all start up/recovery actions, such as the actions described above, and all of the actions normally performed during initial power-on:
- o Turn equipment off or on:
- o Change equipment parameters; or
- o Change threshold levels/values.

Remote control and adjustment capabilities and commands for the VOR/DME RMS shall be documented in the contractor-prepared VOR/DME-MPS ICD as specified in paragraph 3-3.3.1.13.

The RMS shall perform the required command action by selecting and executing the appropriate process control algorithm or diagnostics function are the same as those required for the monitoring and alarm reporting functions.

3.3.4.2.5.2.1 Demand diagnostics. - The VOR/DME RMS shall control and perform the actual diagnostics. The subfunctions performed by the RMS in support of the demand diagnostic function are presented below.

1. Received Message. A Fault Diagnostic Command message may be addressed to a logical unit, or the PMDT, as well as the RMS, at the contractor's design option. In this event, a Fault Diagnostic Command message received by the RMS shall be examined upon receipt to determine whether it is to be processed by the RMS or the PMDT or retransmitted to a VOR/DME subsystem. The address code transmitted as part of the message shall be examined to see if the message has reached its final destination.

2. Interpret Message. After establishing that the message has reached its intended destination, the message shall be interpreted to determine what action is required of the RMS. The message function code transmitted with the Fault Diagnostic Command message shall be decoded, determining that the RMS is required to perform either fault or parameter diagnostics on the equipment.

3. Run Diagnostic Test. After interpreting the Fault Diagnostic Command message, the RMS shall run one of two types of diagnostics routines on the equipment, namely, fault or parameter.

4. Obtain Diagnostic Results. The acquisition of fault data shall be performed by the data acquisition subsystem of the RMS. This subsystem shall provide the interface between the RMS and the actual equipment. It shall consist of sensors which shall be embedded in the VOR/DME equipment being diagnosed.

5. Condition Diagnostic Results. The data acquired from the sensors may require conditioning prior to being processed by the RMS. Some conditioning and data conversion shall be automatically performed by the processor subsystem of the RMS. The necessary processing of this data shall take place at the RMS and the result of this processing shall be either identification of the bad LRU or the fault information.

6. Format Diagnostic Results. The fault data collected by the RMS sensors shall be formatted into a Fault Diagnostic Result message, which shall have the form of a Site Data Report, as defined in NAS-MD-790.

3-3.4.2.5.2.2 Automatic diagnostic. - The VOR/DME RMS shall have the capability to acquire fault information automatically (i.e., without any human intervention). This capability is referred to as automatic diagnostics. It differs from demand diagnostics primarily in the way the process is initiated and controlled. It shall be completely initiated and controlled by an RMS, as opposed to an authorized person. That is, once the VOR/DME RMS detects an alarm it shall automatically run a diagnostics test to identify the faulty LRU(s).

This automatic diagnostic function shall be identified as a distinct logical unit (LU) within the VOR/DME RMS. Once the diagnostics test is complete, the data acquired from the test shall be formatted into a Fault Diagnostics Report logical unit message, having the form of a Site Data Report, as defined in NAS-MD-790. This message then shall be transmitted up-line as the RMS's response to an MPS poll of this logical unit.

3-3.4.2.6 Physical security function

3-3.4.2.6.1 Objective. - The physical security component shall handle the monitoring and reporting of access to VOR/DME facilities and the detection and reporting of smoke within these facilities. The objective of the physical security function is to provide for immediate notification of instances of intrusion, smoke or fire at equipment facilities housing RMSs. This function shall provide for improved response times for handling such occurrences.

3-3.4.2.6.2 Process description. - The physical security function can be viewed as a subfunction of the alarm function. Like the alarm function, it shall provide for immediate notification to the personnel having responsibility for the VOR/DME facility. It shall also be driven by events that occur at the VOR/DME site. However, unlike the alarm function, the physical security function will not be concerned with the performance of the equipment at the VOR/DME site but will only be concerned with the security of the remote site.

Physical security processing shall be initiated and driven by actions that occur at the VOR/DME site. A detailed description of the processing that the VOR/DME RMS shall perform in order to detect and report instances of smoke and unauthorized entry at the VOR/DME site is presented below.

1. Get Discrete Data. The VOR/DME facility shall have sensors to detect the presence of smoke and the opening of doors. These sensors shall be monitored on a continuous basis by the RMS in the same way that the RMS shall monitor equipment performance parameters. The retrieval of data from these sensors, by the RMS, shall be automatically

performed without a need for commands from the MPS or system user.

2. Retrieve Alarm State Values. Instances which warrant the generation of a security alarm shall be determined by comparing the sensor state values obtained with "normal" state values for each sensor. The normal state values shall be maintained in the RMS's data base. As part of the alarm checking process, the RMS must automatically retrieve the necessary normal state values from its data base.

3. Compare Data. The outputs from the security sensors shall be compared with their respective normal state values. This comparison shall establish if an alarm condition exists, and if so, what kind of security alarm. An alarm state comparison must also be performed to determine if the, current state represents a change from a non alarm state to an alarm state or vice versa. The results from these comparisons shall provide the basis for generating any alarm messages.

4. Generate Alarm or Status Change Message. If the comparison of the sensor outputs with desired values indicates that an alarm or status change condition exists, the RMS shall generate the appropriate message for transmission up-line to the MPS. When a smoke or intrusion alarm state is identified, an Alarm State Report shall be generated by the RMS. If an alarm goes to a non-alarm condition, a return-to-normal message will be forwarded to the MPS for that parameter.

3-3.4.2.7 Process security function

3-3.4.2.7.1 Processing

The process security function controls access to the VOR/DME RMS through the PMDT, using security functions provided by the MPS. The RMS shall normally be in remote control mode, whenever communications to the MPS are available. The PMDT shall be used by an on-site maintenance technician to obtain local control from the MPS when required, and shall receive local control from the RMS on MPS communications failure. On-site security provided by the RMS shall control PMDT access to the RMS under all circumstances.

3-3.4.2.7.1.1 On-site security

The RMS shall sense for the connection of a PMDT to its serial port on the FCPU, and offer a prompt for on-site entry sign-on. A two-step sign-on command, when correctly entered, shall cause the VOR/DME RMS to respond to subsequent commands. Since the user password identifiers equate to various levels of security, each command entry shall be validated against the applicable security level list before execution. Each sign-on command entry shall be reported to the MPS. At least 24 unique six-character user password identifiers shall be provided. These passwords shall be maintained as an On-Site Security logical unit for remote administrative maintenance.

The first step shall consist of the operator entering his user identification. The second step shall consist of the operator entering his password. Neither the identifier characters nor the password characters shall be displayed. Invalid entries shall be flagged as errors, and shall cause the access procedure to halt and return to the idle (wait) sequence. A timer shall be provided to require a sign-on procedure to be repeated if the interface is idle for more than 15 minutes. Any valid messages transmitted over the interface shall reset this timer.

The first level password (highest) shall give access to all possible data and command executions, including MPS access during remote operation. The second level shall provide access to all data, and controls for changing alert limits, during local operation. The third level shall provide access to environmental data and status of VOR/DME equipment only.

These levels of security are intended to control stand-alone operation during installation, and maintenance at an installed VOR/DME site in the absence of MPS communications. The level of security established during entry shall not restrict operator access to MPS during remote control mode, or MPS security for change to local control mode.

3-3.4.2.7.1.2 Remote control mode security.

PMDT entry, at any level of on-site security, shall provide access to commands requesting MPS access as a standard Maintenance Data Terminal (MDT). The VOR/DME RMS must pass all communications through between PDMT and MPS without alteration during such access. The MPS security procedures shall apply to all PMDT access to RMM databases and commands, as follows; no RMS functions are necessary to implement the following procedures.

When logging on through the MPS logon screen and using information typed on that screen (facility ID, cost control center, MPS password), user authorization and equipment assignment records maintained in the MPS data base will be checked to determine whether or not the requester is authorized to access the specific VOR/DME site originating the request. If the results of this check indicate that the requester is not authorized, a message refusing the logon will be generated by the MPS and routed to the data requester's terminal for display.

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These levels of security are intended to control stand-alone operation during installation, and maintenance at an installed VOR/DME site in the absence of MPS communications. The level of security established during entry shall not restrict operator access to MPS during remote control mode, or MPS security for change to local control mode.

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PMDT entry, at any level of on-site security, shall provide access to commands requesting MPS access as a standard Maintenance Data Terminal (MDT). The VOR/DME RMS must pass all communications through between PDMT and MPS without alteration during such access. The MPS security procedures shall apply to all PMDT access to RMM databases and commands, as follows; no RMS functions are necessary to implement the following procedures.

When logging on through the MPS logon screen and using information typed on that screen (facility ID, cost control center, MPS password), user authorization and equipment assignment records maintained in the MPS data base will be checked to determine whether or not the requester is authorized to access the specific VOR/DME site originating the request. If the results of this check indicate that the requester is not authorized, a message refusing the logon will be generated by the MPS and routed to the data requester's terminal for display.

with a centralized capability for initializing the RMS's computer system.

3-3.4.2.8.2 Process description. - The system initialization function shall verify that the FCPU and RMS software are fully operational, and load initial parameters from non-volatile memory. The function shall then permit authorized system users to clear or set counters and registers to their starting values, and to load any necessary variable or constant values which have to be reloaded before an RMS can be started after a shutdown, and to restart the shutdown RMS.

Implementation of the system initialization function shall involve the use of the PMDT and the MPS. A detailed description of the RMS related processing requirements for the system initialization function is presented below.

System Initialization Process. - Start-up or reinitialization of the VOR/DME RMS shall be initiated through the entry of a Start-up/Recovery Command message via an MDT located at the MPS, or via a PMDT in local control mode. Upon receipt of a Start-up/Recovery Command, the VOR/DME RMS shall automatically execute whatever actions are required to restart the RMS (e.g., perform self-tests, clear registers, reset counters, etc.). Start-up/Recovery actions may include the reloading of a remotely loadable data base for site-specific data (500 bytes maximum).

1. Receive Start-up/Recovery Command. When a message has been received by the RMS, it shall be examined upon receipt to determine if it is to be processed by the RMS or retransmitted to the PMDT. The address code transmitted as part of the Start-up/Recovery Command message shall be examined to determine if the message has reached its final destination.

2. Interpret Message. After establishing that the Start-up Recovery Command has reached its final destination, the message function code transmitted as part of the message shall be decoded to determine what action is required by the RMS. This determination shall be accomplished through the use of a message ID file maintained in the RMS's data base. The decoding activity shall establish that the RMS is to perform all of the actions required to start-up or restart the RMS.

3. Execute RMS Start-up/Recovery Actions. Upon recognizing that a Start-up/Recovery Command has been received, the VOR/DME RMS shall perform all necessary reset operations (e.g., clear all/any monitored data samples, set internal registers to zero, unlock any automatic switchover functions which may be disabled, perform self-tests, etc.) and verify the success of these reset operations. Failure of these

operations shall result in an alarm condition. The VOR/DME RMS shall have a remotely loadable data base capability, and therefore, on success of the reset operations, shall also generate the Data Base Download Request message required to have the data for the data base downloaded from the MPS.

4. Transmit Data Base Download Request. The Data Base Download Request message generated by the RMS shall be placed in the appropriate transmit buffer or temporary storage location until it can be transmitted in response to a poll from the MPS. Upon receipt of the request message, the MPS shall format the requested data into a Data Base Download message, and transmit the Data Base Download message to the RMS.

5. Receive Data Base Download Message. When the Data Base Download message is received by the RMS, it shall be subjected to the same sequence of examinations as the Start-up/Recovery Command message. Decoding of the message function code transmitted as part of the Data Base Download message shall establish both the receipt of the requested data base data, and that the contents of the message just received are to be stored in the RMS's non volatile memory.

6. Store Message Contents. Upon recognizing that it has received a Data Base Download message, the VOR/DME RMS shall automatically extract the transmitted data and store the individual data items in their respective storage locations in the RMS's memory.

7. Complete Start-up/Restart Actions. When the requested data has been stored, the RMS shall complete any initialization actions which were not completed prior to the receipt of the requested data base data. After all start-up actions have been completed, the RMS shall automatically transfer control of the RMS from the start-up programs to the command processor component of the RMS.

8. Confirm RMS Start-up/Restart. After start-up/restart actions have been successfully completed, the RMS shall generate and transmit up-line a Data Base Download Acknowledgement message and a Start-up/Recovery message. The Data Base Download Acknowledgement message shall be used to inform the MPS that the downloading of the data base items was successful. The Start-up/Recovery Result message shall be routed to the user terminal from which the Start-up/Restart command message, which started the initialization process, originated. Receipt of the Start-up/Recovery Result message at the user terminal shall mark the end of the session.

If the restart of RMS is being performed at the local site, all transmissions stated as being to and from the MPS will, instead, be to and from the PMDT connected to the RMS.

3-3.4.2.9 System performance function.

3-3.4.2.9.1 Objective. - The objective of the system performance function is to provide information to evaluate the performance of the VOR/DME RMS; this function will control the monitoring and recording of performance data on the hardware and software components of the VOR/DME RMS, and its dissemination to required personnel or storage in an appropriate data base file. It shall provide the means for detecting RMS failures and contributors to the unacceptable performance of the RMS.

3-3.4.2.9.2 Process description. - As a system support function, the system performance function shall not be concerned with the operation of the operational equipment that the primary RMM functions shall be concerned with. This function will be responsible for monitoring and recording data on the performance of the RMS itself. Failures of RMS components shall be determined through the use of RMS performance data collected under the system performance function. The actual determination of a failure or impending failure of the VOR/DME RMS component shall be accomplished as part of the alarm recognition processing described for the Alarm Function.

Included in the design of the VOR/DME RMS shall be sensors and application programs to monitor the performance of the VOR/DME RMS hardware and software. These hardware and software monitors shall automatically monitor and record information on the status and use of the RMS's hardware and software elements. This information will be stored at the RMS, as a logical unit, for use in determining alarm conditions for the RMS. The parameters in the RMS Logical Unit, like other parameters, shall be available for retrieval by the MPS (the remote control mode) or through the use of a PMDT at the facility site (the local control mode). When a VOR/DME RMS is being operated in the remote control mode, the retrieval of RMS performance data shall be controlled by the MPS. When a VOR/DME RMS is being operated in the local control mode, the retrieval of this data shall be controlled by the individual at the RMS site. To minimize redundancies, only the collection of RMS performance data while an RMS is being operated in the remote control mode shall be addressed in the remainder of this process description.

When a VOR/DME RMS is in the remote control mode, RMS performance data shall be transmitted up-line in response to an MPS generated data request based upon a schedule requirement or a need by another processor (referred to herein as Automatic System

Performance), or in response to a request from an authorized system user (referred to herein as Demand System Performance).

3-3.4 2.9.2.1 Automatic system performance. - The RMS shall control and perform the retrieval of its system performance data. The actions performed by the RMS during the acquisition, storage, and transmission up-line of this data are described below.

1. System Performance Data Retrieval. The RMS shall be designed with a self-monitoring capability. This capability shall allow for the collection of the data needed to detect the failure or impending failure of RMS components, and to evaluate the performance, efficiency, and utilization of the VOR/DME RMS as opposed to the VOR/DME equipment.

Given that many of the capabilities of the RMS shall be provided through the use of software, instead of hardware, software monitors shall be used in conjunction with hardware monitors. Together, the hardware and software monitors shall collect the data needed to evaluate the utilization of the RMS's memory and CPU, track the effect of changes to the RMS's hardware and software, detect voltage fluctuations in the RMS equipment or the failure of a component of the RMS. The system performance monitors shall also provide the means for maintaining records on the RMS's transaction related activities. The retrieved RMS performance data shall be conditioned and scaled, when appropriate, and stored in such a manner that it shall be retrievable separate from the facility performance data also being retrieved and stored by the RMS.

2. Receive Specific Poll. All transmissions received by the RMS shall be examined upon receipt to determine if they are to be processed by the RMS or retransmitted to the PMDT. The RMS shall examine the address data included in the subject specific poll. The receipt of a specific poll for system performance data shall be established at this point. The response required of the RMS shall be to format the RMS's system performance data and transmit it up-line to the MPS.

3. Retrieve and Format Data. After establishing that it has to transmit its system performance data up-line, the RMS shall retrieve the required data from its data base and format the data for transmission. The data shall be transmitted in the form of a Parameter Response message. Formatting shall involve placing the data elements in their appropriate message fields and adding the necessary communication control characters to the actual message.

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3-3.4.3.2.1.1.1.2 Component enumeration. - By explicit enumeration, each message defined for the **VOR/DME RMS** shall be separately presented. At each level, an identification code shall be used to enable convenient reference of the component in higher levels. A name or phrase shall be used to establish the basic role of the component (such as "measured parameter **value").** The actual component description shall be in terms of data elements and fields. Additional descriptive data shall be given through use of examples with supporting interpretation.

3-3.4.3.2.1.1.1.3 Dependencies. - A message format may be **request-** or state-dependent. A command assembled within the **MPS** and transmitted to the **RMS** may implicitly define the format of the return message, which is thus request-dependent. The data contained in the request may be the basis for determining the format of the response. Similarly, the state of the **RMS** may also determine the message format. The range of possible dependency classes is as follows:

(**RISI**) Request Independent, State Independent: Message type and location is adequate to access **RMS** resident table(s) for all necessary format information **(pre-defined).**

(**RDSI**) Request Dependent, State Independent: **RMS** resident tables augmented by information derived from the request.

(**RISD**) Request Independent, State Dependent: **RMS** resident tables augmented by information derived from the message itself.

(**RDSD**) Request Dependent, State Dependent: **RMS** resident tables augmented by information from the request and information derived from the message itself.

VOR/DME RMS messages shall each be identified with one of these dependency classes.

3-3.4.3.2.1.1.2. Data elements. - Data elements shall be the first organizational level in the message structure. A data element is here defined as a string of octets where the interpretation of the octets is consistent (ASCII characters, **BCD** digits, binary number, etc.), and the string has a fixed application dependent meaning. For example, a parameter value may be an absolute value of voltage transmitted as a sixteen-bit binary number, thus defining the data element of the value itself as a two-octet binary number.

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(**RDSI**) Request Dependent, State Independent: **RMS** resident tables augmented by information derived from the request.

(**RISD**) Request Independent, State Dependent: **RMS** resident tables augmented by information derived from the message itself.

(**RDSD**) Request Dependent, State Dependent: **RMS** resident tables augmented by information from the request and information derived from the message itself.

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3-3.4.3.2.1.1.3 Fields. - Fields are the second organizational level in the message structure. A field is here defined as a string of data elements organized in such a way as to be a self-contained, meaningful element of information.

Standard field types are enumerated in Figure B. It is from this catalog of types that particular fields shall be chosen. As with data elements, the field types are named and their structure defined in terms of data elements.

FIELD TYPE	PARAMETERS	
FIXED NUMBER OF DATA ELEMENTS	NDE:	NO. OF DATA ELEMENTS
VARIABLE NO. OF REPEATING GROUP OF DATA ELEMENTS	NDG:	NO. OF DATA ELEMENTS IN REPEATING GROUP
CONSTANT NO. OF REPEATING GROUP OF DATA ELEMENTS	NDG:	NO. OF DATA ELEMENTS IN REPEATING GROUP
	J:	NO. OF REPEATING GROUPS
CONSTANT NO. OF DATA ELEMENTS FOLLOWED BY VARIABLE NO. OF REPEATING GROUPS	k1:	NO. OF DATA ELEMENTS IN CONSTANT GROUP
	k2:	NO. OF DATA ELEMENTS IN REPEATING GROUP
CONSTANT NO. OF DATA ELEMENTS FOLLOWED BY FIXED NO. OF REPEATING GROUPS	k1:	NO. OF DATA ELEMENTS IN CONSTANT GROUP
	k2:	NO. OF DATA ELEMENTS IN REPEATING GROUP
	J:	NO. OF REPEATING GROUPS

FIGURE B: STANDARD FIELD TYPES

3-3.4.3.2.1.1.4 Messages. - Messages are the third and highest organizational level in the allowed message structure. A message is here defined as a string of fields organized in such a way as to permit proper association of the fields with corresponding processing routines.

Standard message types are enumerated in Figure C. It is from this catalog of types that **VOR/DME RMS** messages shall be constructed.

MESSAGE TYPE	PARAMETER
FIXED NO. OF FIELDS	**NF:** NUMBER OF FIELDS
REPEATING FIELD GROUP - VARIABLE	**k2:** NO. OF FIELDS IN REPEATING GROUP
REPEATING FIELD GROUP - FIXED	**k2:** NO. OF FIELDS IN REPEATING GROUP
	J: NO. OF REPEATING GROUPS
VARIABLE NO. OF REPEATING FIELD GROUPS OF VARIABLE REPETITIONS EACH	**k2(i):** NO. OF FIELDS IN i^{th} REPEATING GROUP
FIXED NO. OF REPEATING FIELD GROUPS OF VARIABLE **REPITI-TIONS** EACH	**k2(i):** No. OF FIELDS IN i^{th} REPEATING GROUP
	J: NO. OF REPEATING GROUP STRUCTURES
VARIABLE NO. OF REPEATING FIELD GROUPS OF FIXED REPETITIONS EACH	**k2(i):** NO. OF FIELDS IN i^{th} REPEATING GROUP
	I: NO. OF REPEATING GROUPS IN i^{th} STRUCTURE OF REPEATING GROUPS
FIXED NO. OF REPEATING FIELD GROUPS OF FIXED REPETITIONS EACH	**k2(i):** NO. OF FIELDS IN i^{th} REPEATING GROUP
	I(j): NO. OF REPEATING FIELD GROUPS IN i^{th} REPEATING GROUP
	J: NO. OF REPEATING GROUP STRUCTURES

FIGURE C: STANDARD MESSAGE TYPES

3-3.4.3.2.1.2 Application protocol operation. - These factors shall be discussed in the Application Layer section of the VOR/DME-MPS ICD.

1. Normal Cycle: the normal cycle of operation to periodically retrieve data,

2. Alarm Responses: the sequences of events in response to alarm situations.

3. Commands and Responses: the sequences of events to effect execution of commands from the MPS to RMS.

4. RMS performance: the sequence of events to obtain status data pertaining to the performance of the RMS.

3-3.4.3.2.1.2.1 Operations representation. - The VOR/DME-MPS ICD shall present operations associated with message sequences using flow charts to describe processing and message sequence dependencies. The use of flow charts in describing such operations is to abide by the symbol conventions established in FIPS-PUB-24. In conjunction with the flow charts, specific message dependencies and transmission sequences shall be illustrated in time sequence diagrams comparable to those used in NAS-MD-790, section 4.4 and following, or Appendix C to ANSI X3.66 ADCCP.

3-3.4.3.2.1.2.2 Normal cycle operation. - The normal cycle of operation consists of the routine sequence of events describing the exchange of messages between the RMS and MPS for the periodic retrieval of data. This shall be discussed in the VOR/DME - MPS ICD through a top level system flow chart representing an overview of normal system operation. Other operational factors may be treated as exceptional conditions and discussed through individual flow charts branched off the normal system flow charts. The types and sequences of messages exchanged between the RMS and MPS under the normal cycle operation shall be identified.

3-3.4.3.2.1.2.3 Alarm responses. - Alarm responses consist of the exceptional sequence of events occurring outside the normal cycle operation. The VOR/DME - MPS ICD shall describe the exchange of messages upon the occurrence of each alarm condition. When the RMS detects an alarm condition, an exception condition shall be presented in system flow charts as a hardware or software interrupt of the normal cycle, in which the RMS shall assemble the alarm message according to the specified format and report the alarm message to the MPS in response to polling. The expected MPS responses after the receipt of the alarm messages shall also be discussed using time sequence diagrams. The discussion shall describe the

RMS return to normal cycle operation, concluding the exceptional sequence.

Because the sequence of events for reporting the alarm message to the MPS is dependent on the particular RMS operational state at the time of the alarm, the discussion of RMS alarm response in the VOR/DME-MPS ICD shall consider at a minimum the following cases of RMS operational state:

a. Alarm during the process of transmitting data or a command message to the MPS,

b. Alarm during the process of receiving a command message from the MPS,

c. Alarm during the state of being ready for transmitting the necessary alarms.

<u>3.3.4.3.2.1.2.4 Command responses.</u> - Command responses consist of the sequence of events required to effect execution of commands from the MPS to the RMS. Discussion of command responses in the VOR/DME-MPS ICD shall include the following:

a. Types of MPS generated commands:

b. RMS processing events for each type of command using flow charts:

c. RMS message exchanges with MPS during the complete processing of each command, using time sequence diagrams.

<u>3.3.4.3.2.1.2.5 RMS system performance.</u> - RMS system performance consists of all factors considered in evaluating success of the VOR/DME RMS in its mission. RMS system performance parameters shall make up the RMS Master logical unit identified in NAS-MD-790 section 3.2.2.1. The VOR/DME-MPS ICD shall describe as a minimum the following factors for RMS system performance:

a. RMS-MPS communications performance;

b. Normal cycle processing performance:

c. Alarm processing performance;

d. Command processing performance.

Performance parameters and alarm thresholds for each of these factors shall be fully described. Normal, alarm, and command

RMS return to normal cycle operation, concluding the exceptional sequence.

Because the sequence of events for reporting the alarm message to the MPS is dependent on the particular RMS operational state at the time of the alarm, the discussion of RMS alarm response in the VOR/DME-MPS ICD shall consider at a minimum the following cases of RMS operational state:

a. Alarm during the process of transmitting data or a command message to the MPS,

b. Alarm during the process of receiving a command message from the MPS,

c. Alarm during the state of being ready for transmitting the necessary alarms.

3.3.4.3.2.1.2.4 Command responses. - Command responses consist of the sequence of events required to effect execution of commands from the MPS to the RMS. Discussion of command responses in the VOR/DME-MPS ICD shall include the following:

a. Types of MPS generated commands:

b. RMS processing events for each type of command using flow charts:

c. RMS message exchanges with MPS during the complete processing of each command, using time sequence diagrams.

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a. RMS-MPS communications performance;

b. Normal cycle processing performance:

c. Alarm processing performance;

d. Command processing performance.

Performance parameters and alarm thresholds for each of these factors shall be fully described. Normal, alarm, and command

3-3.4.3.2.4 Performance requirements

RMS process control response time requirements are as follows:

Time (sec)	Action
2 avg, 5 max	RMMS control command initiation and execution
2 avg, 10 max	Alarms/alerts, Return-to-Normal, state change detection and presentation
50 avg, 240 max	Performance data collection
2 avg, 5 max	Request/reply acknowledge

3-3.4.4. VOR/DME specific RMS software requirements

3-3.4.4.1 Master shutdown command

As required in 3-3.3.1.1(i), the VOR/DME RMS shall implement a Master Shutdown command which shall cause the entire VOR/DME installation to shut down without delay.

3-3.4.4.2 Subsystem shutdown commands

In addition, the VOR/DME RMS shall implement Subsystem Shutdown commands for VOR with monitor, DME with monitor, and FCPU. (See 3-3.3.1.1.(i))

3-3.4.4.3 Master and subsystem recovery commands

The VOR/DME RMS shall implement Startup/Recovery commands for each subsystem that can be separately shut down, and for the entire VOR/DME installation (as distinct from RMS Startup/Recovery required by NAS-MD-790). (See 3-3.3.1.1.(i))

3-3.4.4.4 Engineering units

All data monitored and displayed shall use standard engineering units, requiring no further correction or mathematical calculation. (3-3.3.1.1.(b))

3-3.4.4.5 Arbitrary parameter groups

In addition to predefined Logical Units grouping parameter data points, the VOR/DME RMS shall provide a Logical Unit that can provide arbitrary groupings of parameters as identified in 3-3.3.1.1.(e) herein.

3-3.4.4.6 Large "pass-through" messages

The VOR/DME RMS software shall provide blocking and deblocking of "pass-through" messages up to 4000 bytes in length into NAS-MD-790 terminal messages of no more than 500 bytes per message.

3-3.4.4.7 Fail-safe requirement

The VOR/DME RMS software shall meet the fail-safe requirements of 3-3.3.1.1(h) and 3-3.5 herein.

3-3.4.4.8 Communications interface requirements

The physical layer of the VOR/DME-MPS interface shall meet requirements of 3-3.3.1.2.1 and 3-3.3.1.4.

3-3.4.4.9 Alarm and alert processing

The VOR/DME RMS shall generate alert and alarm messages in accordance with NAS-MD-790 and requirements of 3-3.3.1.7 through 3-3.3.1.7.2 and 1-3.3.19 herein.

False alarm handling shall follow requirements of paragraph 3-3.2.7 herein.

3-3.4.4.10 Logical units and addressing

Groups of parameters are named as "Logical Units" by the RMS, as described in 3-3.4.1.1.2.2. These are in turn identified as sub-addresses of the communications address of the RMS in NAS-MD-790. The VOR/DME system address of 3-3.3.1.7 is the RMS communications address identified in NAS-MD-790 section 3.2. All logical unit addressing shall conform to these requirements.

The following logical units (LUs) are required by NAS-MD-790 section 3.2.2: RMS master LU, RMS terminal (FCPU/PMDT) communications LU, VOR/DME environmental and site security LU, and RMS communications LU.

In addition, the following logical units shall be provided for VOR/DME: Master and Subsystem Shutdown/Recovery LUs, Database Download Request LU, Auto Diagnostics LU, Auto Certification LU, RMS Security LU, and RMS Clock LU.

Other VOR/DME LUs shall be designated by the contractor in the VOR/DME - MPS ICD. The following LUs shall be provided as a minimum: Master Status LU, VOR Status LU, DME Status that can provide arbitrary groupings of parameters as identified in 3-3.3.1.1.(e) herein.

3-3.4.4.6 Large "pass-through" messages

The VOR/DME RMS software shall provide blocking and deblocking of "pass-through" messages up to 4000 bytes in length into NAS-MD-790 terminal messages of no more than 500 bytes per message.

3-3.4.4.7 Fail-safe requirement

The VOR/DME RMS software shall meet the fail-safe requirements of 3-3.3.1.1(h) and 3-3.5 herein.

3-3.4.4.8 Communications interface requirements

The physical layer of the VOR/DME-MPS interface shall meet requirements of 3-3.3.1.2.1 and 3-3.3.1.4.

3-3.4.4.9 Alarm and alert processing

The VOR/DME RMS shall generate alert and alarm messages in accordance with NAS-MD-790 and requirements of 3-3.3.1.7 through 3-3.3.1.7.2 and 1-3.3.19 herein.

False alarm handling shall follow requirements of paragraph 3-3.2.7 herein.

3-3.4.4.10 Logical units and addressing

Groups of parameters are named as "Logical Units" by the RMS, as described in 3-3.4.1.1.2.2. These are in turn identified as sub-addresses of the communications address of the RMS in NAS-MD-790. The VOR/DME system address of 3-3.3.1.7 is the RMS communications address identified in NAS-MD-790 section 3.2. All logical unit addressing shall conform to these requirements.

The following logical units (LUs) are required by NAS-MD-790 section 3.2.2: RMS master LU, RMS terminal (FCPU/PMDT) communications LU, VOR/DME environmental and site security LU, and RMS communications LU.

In addition, the following logical units shall be provided for VOR/DME: Master and Subsystem Shutdown/Recovery LUs, Database Download Request LU, Auto Diagnostics LU, Auto Certification LU, RMS Security LU, and RMS Clock LU.

Other VOR/DME LUs shall be designated by the contractor in the VOR/DME - MPS ICD. The following LUs shall be provided as a minimum: Master Status LU, VOR Status LU, DME Status

3-3.4.5.1 Operating software requirements

Section	Requirement
3-3.3.2.7	VOR and DME redundant monitor management
3-3.3.1.13	FCPU to VOR transmitter, VOR monitor, DME transponder, and DME monitor equipment internal interface documents
3-3.3.2.2.1	FCPU access to test equipment (driver software)
1-3.3.19	Assist the VOR and DME monitors in performing the auto-reset function
3-3.3.2 and following	Adjustment, testing and control functions
1-3.3.13.1	Operator interface requirements through the PMDT
3-3.3.1.11	VOR/DME security requirements
3-3.2.4	Pre-fault data collection
3-3.2.5	Post-fault data collection
3-3.2.6	False alarm data collection
3-3.2.7	Post alarm data collection
1-3.3.9	Non-volatile memory requirement
4-3.3.1.3	Access to VOR transmitter parameters, status, and controls
5-3.3.3	Access to VOR monitor parameters, status, and controls
5-3.3.8.9	VOR monitor alarm signals
6-3.4.3.5.2	DME transponder triggering level and desensitization duration settings
6-3.4.3.6	Access to DME transponder information on traffic load
6-3.4.5	Handle the DME transponder keyer on VOR keyer failure

7-3.4.3.1	**DME** monitor alarm actions
3-3.3.2.4	**VOR** certification
3-3.3.2.5	**DME** certification
3-3.3.2.3	Test generator functions
3-3.3.2.7.2	Ground check functions
3-3.3.2.8, 3-3.3.2.10	Environmental parameter monitoring
3-3.3.2.9.	External systems test
3-3.3.3.1, 3-3.4.2.2.7	Communications protocol driver
3-3.3.3.1	Analog communications circuit management
3-3.3.4	Voice identification circuit management
3-3.3.4.6	Voice output level adjustment
3-3.3.1.12	Handling of communications failure
3-3.4.5.2.4, 5-3.3.8.10	**VOR keyer** management
3-3.4.1.5	Trend analysis data collection

3-3.4.6 Fault Diagnosis software

The **FCPU** software shall contain functions required to perform fault diagnosis required in **1-3.3.7.** This fault diagnosis software shall be implemented with a minimum of dependence on other software: in particular, it shall be possible to perform fault diagnosis during **VOR/DME** installation without **RMS** or operational software present. Automatic means shall be provided to diagnose the cause of a fault to the **LRU** level (see paragraph **1-3.1.20).** The resulting data shall be stored in memory at the facility and shall be accessible via the **FCPU** for recall upon demand by the **RMS,** for use as the Auto Diagnostic Logical Unit data. The diagnostic software shall be automatically initiated by the **RMS** when an alarm or an alert occurs except when the condition is the result of an environmental sensor parameter of paragraph **3-3.3.2.10.1** through **3-3.3.2.10.5** herein. Additional manually initiated diagnostics shall be available from the **PMDT** interface to offer more detailed information on the subsystem status to aid the maintenance process. The results of the automatic diagnostics test shall be stored in memory at the FCPU until reset at the PMDT interface or from the RMS.

3-3.4.7 Installation and checkout software

Installation and checkout software shall implement or support test and control sequencing for stand-alone installation and system integration (under local PMDT control using utility software described below) and operational master and subsystem startup/recovery, automatic certification, and demand certification (under RMS control).

3-3.4.8 Utility software

3-3.4.8.1 FCPU utility software

In addition to the above software, the contractor shall provide whatever non-operational FCPU software is necessary to support integration testing, installation, and stand-alone maintenance, for example, software to provide printed reports of stored data described in 3-3.3.1.12.

3-3.4.8.2 PMDT utility software

In addition to the above FCPU software, the contractor shall provide whatever PMDT software, as described in 3-3.3.1.3, is necessary to support integration testing, installation, and stand-alone maintenance -- for example, asynchronous terminal emulation software. Any graphic representation of measured parameters required to improve testing and calibration shall be made available from the menu of commands described in that section. The documentation of PMDT software developed by the contractor, which is required by DOD-STD-2167A, may be included with that of an FCPU CSCI.

(This procurement shall not include the software used with the PMDT of section 3-3.2.16 during normal maintenance operations: this is the MDT/MPS interface and display software provided by FAA to the maintenance technician for normal maintenance operations. Its protocols and display formats are compatible with the IMCS system running in the MPS.)

3-3.5 FCPU fail-safe requirements.- The FCPU specified herein shall be fail-safe in that component failures (one at a time) or an open or short condition of any remote monitor or control line connected to the FCPU shall not prevent the VOR or DME monitor from controlling the shutdown function of the VOR transmitter or DME transponder respectively in the event of a hard alarm.

3-3.6 Reliability.- (See paragraph 1-3.4 of Part 1.)

diagnostics test shall be stored in memory at the FCPU until reset at the PMDT interface or from the RMS.

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Installation and checkout software shall implement or support test and control sequencing for stand-alone installation and system integration (under local PMDT control using utility software described below) and operational master and subsystem startup/recovery, automatic certification, and demand certification (under RMS control).

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3-3.6 Reliability.- (See paragraph 1-3.4 of Part 1.)

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

VOR/DME EQUIPMENT
PART 4 - VOR TRANSMITTER EQUIPMENT

4-1 SCOPE - VOR TRANSMITTER EQUIPMENT

4-1.1 Scope of Part 4.- This Part 4 is one of a group of specification documents under the basic heading "VOR/DME Equipment", each of which carries the basic number FAA-E-2678 together with an alpha revision letter and a slant line and number corresponding to the Part number. This Part 4 of the equipment specified herein consists of the necessary circuitry for generating the navigation signals of a VHF omnirange (VOR) station.

4-1.2 Limitations of Part 4.- This Part 4 does not completely define the requirements for physical and electrical interface with other equipment elements covered under the other parts of the specification, these being the responsibility of the contractor. Additionally, certain requirements are defined only through reference to other parts of the specification.

4-2 APPLICABLE DOCUMENTS.- (See paragraph 1-2 of Part 1.)

4-3 REQUIREMENTS

4-3.1 Equipment to be furnished by the contractor.- Each VOR transmitter furnished by the contractor shall be complete in accordance with all specification requirements.

4-3.2 Definitions.-

4-3.2.1 Goniometer.- The term "goniometer" refers to that unit which produces two RF pure double sidebands which are 30 Hz removed from the VOR carrier frequency. The two 30 Hz components are in audio phase quadrature. Additionally, the goniometer produces a 9960 Hz FM subcarrier signal for amplitude modulating the VOR carrier frequency.

4-3.2.2 Carrier power.- The term "carrier power" is defined as the unmodulated RF power supplied at the transmitter RF output jack during normal operation.

<u>4-3.2.3 Stray radiation.-</u> The term "stray radiation" is defined as emission or leakage of the fundamental frequency signals from the equipment at points other than from the normal equipment output(s).

<u>4-3.2.4 Spurious radiation.-</u> The term "spurious radiation" is defined as emission on a frequency or frequencies other than that of the desired signal(s) and the level of which may be reduced without affecting the corresponding transmission of information. Spurious radiation includes harmonic emissions, parasitic emission, hum, noise, and intermodulation products.

<u>4-3.2.5 Carrier transmitter frequency.-</u> For purposes of this specification the VOR carrier frequency is defined as the VOR channel frequencies shown in Table 1 of Part 1.

<u>4-3.2.6 Mean frequency.-</u> For purposes of this specification, the term "mean frequency" is defined as the number of positive going zero crossings per second, intended specifically for application to frequency modulated signals specified herein after.

<u>4-3.3 General functional requirements.-</u> This equipment is to be used at conventional and Doppler VOR facilities. Interface requirements exist for electrical inputs and outputs. Major performance parameters are response time, output signal spectrum, stability of output signal frequency, level and audio phase.

<u>4-3.3.1 VOR transmitter.-</u> The VOR transmitter shall consist of the following major blocks of circuitry, each designed to perform those functions hereafter specified:

(a) RF source to produce the carrier frequency (as defined in 4-3.2.5).

(b) RF power amplifiers to produce the required power output (4-3.3.3.1) with amplitude modulation levels herein specified (4-3.3.3.7.1) of these audio signals: 9960 Hz FM subcarrier, voice signals 300 through 3000 Hz, identification characters which are keyed 1020 Hz, and 30 Hz.

(c) Automatic level control circuitry shall be contained within the RF transmitter to produce the specified stability (4-3.3.3.1.1).

(d) Automatic phase stability and correction circuitry shall be provided to maintain any preset phase adjustment of the 30 Hz signal applied to amplitude modulate the carrier.

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(c) Automatic level control circuitry shall be contained within the RF transmitter to produce the specified stability (4-3.3.3.1.1).

(d) Automatic phase stability and correction circuitry shall be provided to maintain any preset phase adjustment of the 30 Hz signal applied to amplitude modulate the carrier.

4.3.3.3.1.2 Stabilization of performance characteristics.- See paragraph 1-3.3.18 of Part 1. The equipment contractor shall establish performance requirements for the transmitter (as well as for other individual units of the system) as required to meet the overall requirement= af paragraph 1-3.3.18.

4-3.3.3.2 Output signal spectrum.- Spurious radiation components within the specified frequency bands on both sides of the carrier signal frequency shall not exceed the levels tabulated in the following paragraphs for the modulation type and levels indicated. Except as noted below, all harmonics and spurious radiation greater than 63 kHz removed from the assigned frequency shall not exceed 50 microwatts.

4-3.3.3.3 Amplitude modulation with 9960 Hz FM subcarrier.- The transmitter shall be capable of being amplitude modulated by the 9960 Hz FM subcarrier to a depth of 30 percent ±1 percent. With this modulation level, the levels of the harmonics of the 9960 Hz shall not exceed the values indicated:

Frequency	Level Below Reference
9960 Hz (reference)	0 dB
15 KHz through 18 KHz	15 dB
18 KHz through 27 KHz	32 dB
27 KHz through 37 KHz	52 dB
Beyond 37 KHz	62 dB

4-3.3.3.4 Amplitude modulation with 30 Hz.- The transmitter shall be capable of being amplitude modulated by a 30 Hz signal to a depth of 30 ±1 percent. With this modulation level, the levels of the harmonics of the 30 Hz shall not exceed the values indicated:

Frequency Band	Level Below Reference
30 Hz (reference)	0 dB
60 Hz	32 dB
90 Hz	50 dB
120 Hz	60 dB
Beyond 120 Hz	60 dB

4-3.3.3.5 RF output circuit.- The RF output shall be delivered to the rear of the transmitter via RG-214/U coaxial cable and terminated in an "N" type connector suitable for mating with a UG-1185/U connector. The carrier output circuitry shall be designed to provide the specified performance when feeding an RG-214/U coaxial cable having any values of VSWR in the range of 1.0 through 1.5. The carrier output shall not be required to operate within specification limits for greater values of VSWR, however, no parts of the transmitter shall be damaged as the result of any degree of mismatch, including open and short, at any point on the output transmission line. Adequate protection shall be incorporated into push-pull amplifiers (if used) and multiple (parallel) amplifiers (if used) to prevent loss of both (or more) active devices in the event of failure(s) in any other active device(s). This requirement shall apply to those circuits where automatic level control (ALC) operation could drive circuit elements beyond their ratings.

4-3.3.3.6 Power output measurement.- Directional couplers and detectors shall be incorporated at the carrier output for measurement of forward and reverse power and VSWR by the FCPU, Part 3. Calculated value of VSWR shall be rounded to the hundredth.

4-3.3.3.6.1 Power output calibration.- An internal calibration reference shall be provided to calibrate the power measuring circuitry (4-3.3.3.6) to within ±5 percent. The reference shall be accessible remotely by the FCPU.

4-3.3.3.7 Modulation.- The transmitter shall include the necessary modulation circuitry to produce amplitude modulation at the specified levels.

4-3.3.3.7.1 Amplitude modulation.- The transmitter shall be capable of amplitude modulation to a depth of 80 percent.

4-3.3.3.7.1.1 Amplitude modulation level and stability.- The following amplitude modulation levels for the radiated signal shall be established and maintained within ±1 percent over the range of service conditions:

	Conventional	Doppler
(a) 9960 FM subcarrier	30%	0%
(b) Voice peak 300-3000 Hz	30%	30%
(c) 30 Hz AM signal	0%	30%
(d) 1020 Hz identification	5%	5%

4-3.3.3.7.2 Phase stability for 30 Hz.- The transmitter shall incorporate phase lock loops (PLL) to automatically maintain the stability of the 30 Hz amplitude modulated signal. The phase relation of the 30 Hz audio input and the 30 Hz recovered from the RF amplitude modulated output shall be automatically maintained within ±0.1 degree.

4-3.3.3.8 RF carrier frequency source and stability.- (See paragraphs 1-3.3.14 and 1-3.3.14.1.

4-3.3.3.8.1 RF tuning adjustments.- It shall be possible to tune and adjust the transmitter to meet all performance requirements of this specification on any of the 200 VOR channels utilizing only the integral test equipment, or the integral test equipment and the test equipment specified in paragraph 1-3.5.4

4-3.3.3.9 Tuning and adjustment.- All tuning adjustments and verifications of proper operating levels of the equipment shall be accessible through the FCPU. With the appropriate frequency channel selected, it shall be possible to tune all RF circuits and adjust all required DC, audio, and RF operating levels through voltage and/or current indications on the indicators provided via the FCPU to equipment interface.

4-3.3.3.9.1 Effect of RF circuit detuning.- RF circuit components shall not be damaged as the result of deliberate or inadvertent maladjustment of tuning and level controls over their full range of adjustment. With any unit, assembly or subassembly in its fully accessible state (1-3.3.1.3) there shall be negligible effect on RF and audio tuning and levels.

4-3.3.3.10 Carrier reference sample outputs.- Each equipment shall provide four (4) sample outputs of the carrier output for use in external equipment. Three (3) of these outputs shall be terminated in TNC chassis connectors. The level of the three (3 outputs shall be at least 50 milliwatts into 50 ohms but not greater than 400 milliwatts for any carrier power output level specified in 4-3.3.3.1.1. The fourth output sample shall be terminated in a BNC chassis connector for use with external test equipment (not required to be furnished under this specification). This output shall have a level of not less than 20 milliwatts into 50 ohm load. All coupled sample outputs shall have negligible effect on transmitter system performance and tuning whether these outputs are terminated in 50 ohm load or left unterminated.

4-3.3.3.10.1 Unmodulated carrier reference sample output.- Each equipment shall provide an output of unmodulated carrier RF for use in external equipment. The level of the output to a rear mounted TNC connector shall be at least 40 milliwatts into 50 ohms but not greater than 100 milliwatts for any carrier power output level specified. This RF output shall have negligible effect on transmitter performance and tuning whether terminated in 50 ohms or left unterminated.

4-3.3.3.11 Identification oscillator/keyer.- The identification audio signal generator shall provide a sinusoidal 1020 Hz output signal for keyed or continuous tone to amplitude modulate the carrier output signal. Interface requirements shall exist for keying of the DME in accordance with paragraph 4-3.3.3.11.4.2. Keying may be located within circuitry other than the VOR transmitter.

4-3.3.3.11.1 1020 Hz frequency stability.- The stability of 1020 Hz frequency shall be within ±0.5 percent over the range of service conditions.

4-3.3.3.11.2 Harmonic distortion.- The total harmonic distortion of the 1020 Hz audio signal (continuous tone output) shall not exceed 3.0 percent.

4-3.3.3.11.3 Output level and stability.- The oscillator/keyer shall provide adjustable levels sufficient to amplitude modulate the carrier output 8 percent with a stability which shall maintain the percentage of amplitude of the carrier output to within ±1 percent over the range of service conditions.

4-3.3.3.11.4 Keyer.- The keyer shall operate to key the 1020 Hz audio signal into the dot-dash characters of International Morse Code representing any three- or four-letter combination of the alphabet. The characters shall be readily programmable through the FCPU. The keyer shall be of solid state semiconductor digital design. Motor driven devices to create the keying impulses shall not be used.

4-3.3.3.11.4.1 Identification code characteristics.- The identification code characteristics shall conform to the following:

(a) The dots shall be of duration between 100 milliseconds and 125 milliseconds. The dashes shall be of a duration three times that of the dots.

(b) The spacing between the dots and dashes of a code letter shall be equal to the duration of one dot within ±5 percent.

(c) The spacing between consecutive letters of the three- or four-letter identification code group shall be equal to the duration of three dots within ±5 percent.

(d) The repetition rate for the three-or four-letter identification code group shall be eight times per minute (once in each 75-dot length interval), except as noted under paragraph 4-3.3.3.11.4.2.

4-3.3.3.11.4.2 Synchronization for associated equipment.- The keyer shall be programmed to operate in association with DME equipment such that every fourth identification cycle requirements shall exist for keying of the DME in accordance with paragraph 4-3.3.3.11.4.2. Keying may be located within circuitry other than the VOR transmitter.

4-3.3.3.11.1 1020 Hz frequency stability.- The stability of 1020 Hz frequency shall be within ±0.5 percent over the range of service conditions.

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4-3.3.3.11.3 Output level and stability.- The oscillator/keyer shall provide adjustable levels sufficient to amplitude modulate the carrier output 8 percent with a stability which shall maintain the percentage of amplitude of the carrier output to within ±1 percent over the range of service conditions.

4-3.3.3.11.4 Keyer.- The keyer shall operate to key the 1020 Hz audio signal into the dot-dash characters of International Morse Code representing any three- or four-letter combination of the alphabet. The characters shall be readily programmable through the FCPU. The keyer shall be of solid state semiconductor digital design. Motor driven devices to create the keying impulses shall not be used.

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(b) The spacing between the dots and dashes of a code letter shall be equal to the duration of one dot within ±5 percent.

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4-3.3.3.11.4.2 Synchronization for associated equipment.- The keyer shall be programmed to operate in association with DME equipment such that every fourth identification cycle

4-3.3.3.12.3 Amplifier gain.- The overall gain of the voice frequency amplifier (including regulator circuit and any fixed gain circuits) shall be sufficient to provide amplitude modulation of the 150 watts of carrier power output (4-3.3.3.1) (30 ±1 percent). This requirement shall be met with an input signal of 600 Hz at a level of -26 dBm applied to the input specified in Part 3.

4-3.3.4 Goniometer output characteristics.- The goniometer shall produce the following outputs:

(a) Two RF double sideband outputs which shall be 30 Hz removed from (30 Hz above and below) the carrier reference input 4-3.3.4.2.

(b) 9960 Hz FM subcarrier signal to amplitude modulate the carrier output 4-3.3.3.1.

The RF double sideband outputs contain 30 Hz components which are at audio phase quadrature (90 degrees). These RF double sidebands are combined in the VOR antenna system (not required to be furnished under this specification) in a manner such that a 30 Hz amplitude modulated carrier signal is produced (nominal amplitude modulation is 30 percent). The overall accuracy of the VOR system is dependent on the following parameters of the RF sidebands and the 9960 Hz FM subcarrier:

(a) Equality of power outputs (S.B. #1 = S.B. #2).

(b) Audio phase stability.

(c) Quadrature phase relationship of 30 Hz components of RF outputs, accuracy and stability.

(d) Audio signal distortion.

(e) Audio phase accuracy and stability of the 30 Hz components of RF outputs with respect to 30 Hz component of the 9960 Hz FM subcarrier generator.

(f) RF phase stability.

4-3.3.4.1 Master generator.- To provide azimuth bearing with accuracy and stability, the bearing information generators (30 Hz reference and 30 Hz variable) have prescribed limits within which signal parameters shall remain. The goniometer shall contain a master oscillator which shall operate at a basic frequency which is a multiple of 30 Hz. Crystal ovens are not permitted. Through digital techniques, the basic frequency shall be divided to derive the 30 Hz signals used in each of the following:

(a) 9960 Hz FM subcarrier (4-3.3.4.4) as a frequency modulating signal.

(b) Goniometer sideband (4-3.3.4.3) to produce 30 Hz sidebands with suppressed carrier.

4-3.3.4.1.1 Master oscillator.- At the option of the equipment contractor, the reference oscillator may be either of the tunable frequency or fixed frequency type. The tunable frequency oscillator shall be capable of adjustment to within ±0.005 percent of its design center value and shall have a stability of ±0.01 percent over the range of service conditions. If the contractor elects to provide a non-adjustable oscillator, the precision and stability shall be such as to provide an output frequency which is within ±0.005 percent of the design center value over the range of service conditions.

4-3.3.4.2 Carrier reference.- A carrier output signal sample shall be used as a reference to which the RF phase Of the two double sideband outputs is maintained to within ±3 degrees over the range of service conditions. The carrier reference input to the goniometer shall be obtained from one of the sample outputs specified under 4-3.3.3.10. A suitable amplitude modulation eliminator shall be incorporated into the goniometer design.

4-3.3.4.3 RF output signal characteristics.- The goniometer shall provide two RF double sideband outputs in audio phase quadrature which shall be balanced upper and lower sidebands 30 Hz removed from the carrier reference input (4-3.3.4.2), within the limits of the following subparagraphs. The 30 Hz signal used as the modulation signal is derived from the master generator (4-3.3.4.1). All requirements specified in subparagraphs hereafter shall apply over the range of service conditions. These RF outputs shall be terminated in coaxial chassis connectors suitable for mating with UG-1185/U connectors.

4-3.3.4.3.1 Carrier frequency suppression.- The carrier frequency component present at each goniometer RF output shall not exceed a level which is 30 dB below the power level of the sideband component present at that same output.

4-3.3.4.3.2 Sideband signals power outputs.- Each equipment shall be capable of providing a minimum of 0.25 through 6 watts power output continuously adjustable to each of the two sideband outputs simultaneously with each terminated in 50 ohm resistive loads at the end of a 50-foot length of RG-214/U coaxial transmission line. Power output shall be measured at the load.

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4-3.3.4.3.1 Carrier frequency suppression.- The carrier frequency component present at each goniometer RF output shall not exceed a level which is 30 dB below the power level of the sideband component present at that same output.

4-3.3.4.3.2 Sideband signals power outputs.- Each equipment shall be capable of providing a minimum of 0.25 through 6 watts power output continuously adjustable to each of the two sideband outputs simultaneously with each terminated in 50 ohm resistive loads at the end of a 50-foot length of RG-214/U coaxial transmission line. Power output shall be measured at the load.

±3 degrees and 180 ±3 degrees, referenced to the carrier reference input 4-3.3.4.2.

4-3.3.4.3.8 Deviation from the average maximum envelope amplitude.- For one complete period of the 30 Hz modulation signal, any individual maximum envelope amplitude, at both the outputs, shall not deviate by more than 0.5 percent from the average of all such maximums (averaged over a period of at least five complete cycles of 30 Hz).

4-3.3.4.3.9 Output circuit loading.- The goniometer output circuitry shall be designed to provide the specified performance when feeding a RG-214/U coaxial cable having any value of VSWR in the range of 1.0 to 2.0. The goniometer output shall not be required to operate within specification limits for greater values of VSWR, however, no part(s) of the goniometer shall be damaged as the result of any degree of mismatch, including open and short, at any point on the output transmission line(s). The two RF outputs specified shall be terminated at the rear of the equipment in an "N" type connector suitable for mating with a UG-185/U connector.

4-3.3.4.3.10 Power output during warm up.- The warm up requirements shall be the same as those specified in 4-3.3.3.1.2 for the VOR transmitter.

4-3.3.4.3.11 Power output measurement.- Directional couplers and detectors shall be incorporated at each sideband output for measurement of forward and reverse power and VSWR by the FCPU, see Part 3.

4-3.3.4.4 9960 Hz FM subcarrier generator.- The 9960 Hz FM subcarrier generator provides the "reference" 30 Hz signal for the conventional VOR system. This 30 Hz reference is contained as frequency modulation of the 9960 Hz signal. The following parameter tolerances shall apply to the 9960 Hz FM subcarrier. All requirements shall be met over the range of service conditions.

4-3.3.4.4.1 Mean frequency stability.- The mean frequency (see 4-3.2.6) of the 9960 Hz FM subcarrier signal shall be 9960 Hz ±0.1 percent.

4-3.3.4.4.2 Phase control and stability.- A phase shifter control shall be provided in the 30 Hz signal circuitry of the 9960 Hz FM subcarrier generator. This control shall provide a range of 0.00 to 359.99 degrees of phase shift to the 30 Hz signal. The phase shift shall be in increments of 0.01 degree or less (continuously variable). The phase stability of the 30 Hz component shall remain constant within ±0.1 degree (referenced to the 30 Hz zero crossover(s) of the RF sideband(s)).

4-3.3.4.4.3 Frequency modulation.- The 9960 Hz generator shall be frequency modulated by the 30 Hz audio signal.

4-3.3.4.4.4 Frequency deviation.- The 30 Hz signal shall cause the 9960 Hz generator to deviate by ±480 Hz (deviation ratio of 16). This deviation shall be constant within ±15 Hz. Means shall be provided whereby the deviation ratio may be adjusted to 16 ±0.5.

4-3.3.4.4.5 Level and stability.- The level and stability of the 9960 Hz shall fulfill the requirements of subparagraph 4-3.3.3.7.1.1.

4-3.3.4.4.6 Amplitude modulation.- Amplitude modulation of the 9960 Hz signal shall not exceed a value of 2.0 percent.

4-3.3.5 External input.- Provision shall be made for use of an externally generated 30 Hz audio signal input for use in amplitude modulation of the RF carrier (for Doppler VOR). The 30 Hz external signal source (see paragraph 8-3.3.3.6) has the following characteristics:

Amplitude	Level required to modulate the carrier at any level between 25 and 35 percent
Amplitude stability	±1.0 percent (for any initial adjustment).
Harmonic distortion (total)	2.0 percent maximum.
Frequency	30 Hz +0.1 percent.
Phase stability	+0.2 electrical degrees of 30 Hz (with reference to the zero cross-overs of the audio signal).

4-3.4 Stray radiation.- With the equipment operating at maximum transmitter output (goniometer also at maximum output), stray radiation (4-3.2.3) shall not exceed a level of 14 microwatts effective radiated power. This requirement shall be met with the equipment in or out of its enclosure.

4-3.5 Reliability.- (See paragraph 1-3.4 of Part 1.)

4-4 QUALITY ASSURANCE.- (See paragraph 1-4 of Part 1.)

4-5 PREPARATION FOR DELIVERY.- (See paragraph 1-5 of Part 1.)

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4-3.3.4.4.5 Level and stability.- The level and stability of the 9960 Hz shall fulfill the requirements of subparagraph 4-3.3.3.7.1.1.

4-3.3.4.4.6 Amplitude modulation.- Amplitude modulation of the 9960 Hz signal shall not exceed a value of 2.0 percent.

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Amplitude stability	±1.0 percent (for any initial adjustment).
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Frequency	30 Hz +0.1 percent.
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4-3.5 Reliability.- (See paragraph 1-3.4 of Part 1.)

4-4 QUALITY ASSURANCE.- (See paragraph 1-4 of Part 1.)

4-5 PREPARATION FOR DELIVERY.- (See paragraph 1-5 of Part 1.)

when interconnected with other equipment units comprising a set of ground station equipment.

5-3.2 Definitions.-

5-3.2.1 Monitor equipment.- The term "monitor equipment" denotes a group of integral functioning equipment units consisting of the monitor antenna(s) and monitor interconnected by means of interconnecting cables and extension masts for ground checking of the VOR facility.

5-3.2.2 Monitor antenna.- The term "monitor antenna" denotes an outdoor pickup antenna unit and fiberglass environmental enclosure which is placed in the RF field of the VOR antenna. The output of the monitor antenna is fed to the input of the monitor through interconnecting coaxial cable.

5-3.2.3 FM subcarrier signal.- The FM subcarrier is 9960 Hz signal, frequency modulated at the deviation ratio of 16. This signal is used to amplitude modulate the VOR carrier signal.

5-3.2.4 30 Hz FM signal.- The term "30 Hz FM signal" denotes the 30 Hz obtained by discrimination (or equivalent) of the FM subcarrier signal.

5-3.2.5 30 Hz AM signal.- The term "30 Hz AM signal" denotes the 30 Hz component in the amplitude-demodulated output of the VOR carrier signal.

5-3.2.6 Aural signal.- The term "aural signal" denotes the 300 - 3000 Hz AM components in the demodulated output of the VOR carrier signal. These consist of voice and identification transmissions of the VOR.

5-3.2.7 30 Hz FM channel.- The 30 Hz FM channel comprises the circuits in the monitor which process the FM subcarrier signal to obtain a 30 Hz signal from the 9960 Hz FM subcarrier.

5-3.2.8 30 Hz AM channel.- The 30 Hz AM channel comprises the circuits in the monitor which process the 30 Hz AM signal.

5-3.2.9 Aural channel.- The aural channel comprises the circuits in the monitor which amplify and process the aural signals.

5-3.2.10 Azimuth phase detection circuit.- The azimuth phase detection circuit which compares the phase relation of the signals from 30 Hz FM channel and the 30 Hz AM channel.

This phase difference corresponds with the azimuth position of the monitor antenna about the VOR station, referenced to magnetic north.

5-3.2.11 Test signal circuit.- The test signal circuit is the circuit which provides means for introduction of a simulated VOR composite signal into the monitor.

5-3.2.12 Stray radiation.- The term "stray radiation" is defined as the emission or leakage of the fundamental frequency signal(s) from the equipment at points other than from the normal equipment output(s).

5-3.2.13 Spurious radiation.- The term "spurious radiation" is defined as emission on any frequency or frequencies other than that of the desired signal. Spurious radiation includes harmonic emissions, parasitic emissions, hum, noise, and intermodulation products.

5-3.2.14 Ground check.- The term "ground check" is defined as the measurement of the omnicourse error at several azimuths with respect to a calibrated source.

5-3.2.15 Reference ground check. - "Reference ground check" is defined as the average of three consective ground checks completed immediately following comissioning, recertification or special flight inspection and is used to establish the standard to which subsequent VOR ground check phase error readings are compared.

5-3.3 General functional requirements.- The monitor shall continuously monitor the parameters of the radiated VOR signal and independently determine if an alarm condition exists. If the monitor is not bypassed (paragraph 1-3.1.10.9) and an alarm condition exists, the monitor shall cause the VOR to shutdown. The monitor shall report all parameters, tolerances, and monitor status in accordance with system requirements.

5-3.3.1 Service conditions.- The service conditions shall be those specified in paragraph 1-3.3.15.

5-3.3.2 Power source.- The equipment shall operate from the BCPS specified in Part 2.

5-3.3.3 Facility central processing unit (FCPU) interface.- All parameters, status of monitor, and controls specified herein shall be made accessible on a central buss for remoting with the FCPU as specified in Part 3.

5-3.3.4 30 Hz AM and 30 Hz FM test point isolation.- The 30 Hz AM and 30 Hz FM test points shall be isolated from their respective circuits to the extent that loading each test point with a 1 megohm resistance will not introduce a phase shift greater than 0.1 degree, nor change the value of modulation of the 30 Hz AM by more than 0.2 percent of modulation, nor change the value of 9960 Hz frequency deviation by more than 0.2 Hz.

5-3.3.5 Input signals.- Except as otherwise specified, the monitor equipment shall meet all performance requirements with the monitor antenna operated in a radio frequency signal field having characteristics and modulation components specified in the tabulation below.

Input Signals to Antenna

RF carrier frequency - 108 to 118 MHz
RF field intensity - 0.3 to 3 volts/meter
Polarization - horizontal

Signal Carrier Component	Frequency (Hz)	Percent
30 Hz AM	30 ± 1%	20 to 40
Station Identification	1020 ± 50	4 to 15
Voice	300 - 3000	15 to 40
FM subcarrier	9960 & 480 ± 1%	20 to 40
*30 Hz FM	30 ± 1%	

* Derived from the FM subcarrier signal components within the monitor by discrimination (or equivalent).

5-3.3.5.1 Test signals.- In ground check operation (5-3.3.6) the test signal is the FM subcarrier signal (5-3.2.3) obtained directly from output of the operating goniometer. The test signal (5-3.2.11) consists of the composite 9960 Hz AM signal for periodic calibration verification, and is provided by the FCPU test generator.

5-3.3.6 Ground check system. - The contractor shall provide a 16 point automatic ground check system.

5-3.3.6.1 Ground check.- By utilizing the input signals from the ground check monitor antennas, the VOR monitor azimuth measuring circuits and the test signals (5-3.3.5.1), it shall be possible to measure the azimuth error of the radiated signal to the nearest 0.1 degree. It shall be possible to initiate the automatic ground check routine and to display the results thereof from the PMDT or the MPS.

5-3.3.6.2 Ground check results. - The FCPU shall provide the capability for manual storage of the reference ground check phase error readings (5-3.2.15) in non-volatile memory and to perform the calculations and display the algebraic difference between the reference ground check phase error readings and subsequent routine ground check phase error readings.

5-3.3.6.2.1 Ground check alarm condition. - If the ground check phase error calculations (5-3.3.6.2) indicate a difference in excess of 1.0 degree at any azimuth point, the monitor shall initiate VOR shutdown action in accordance with paragraph 5-3.3.

5-3.3.7 Monitor antenna.- The antennas shall include all components necessary to receive the radiated VOR signal, and shall be assembled so as to enable proper positioning of the components in the radiated field and protection of the components from the elements of nature. The monitor antenna system shall not derogate system performance.

5-3.3.7.1 Broadband characteristics.- The monitor antennas shall have broadband characteristics such that the performance requirements of this specification are met over the specified frequency range without requiring readjustment of the dimensions of the antenna elements.

5-3.3.7.2 Phase balance.- The monitor antenna output shall be balanced with respect to RF phase in such a manner that the indications of the phase difference between the 30 Hz components of the input signal will not differ by more than 0.1 degree when the monitor antenna is situated in the two positions where the dipole antenna extends along a line which is perpendicular to a line between the monitor antenna and the radiating VOR antenna (one position located 180 degrees of dipole antenna rotation about its vertical axis from the other position). The monitor antenna system shall be designed to have impedance matching characteristics.

5-3.3.7.3 Polarization.- The antenna shall be horizontally polarized. Vertical polarized radiation shall be at least 12 dB below horizontal polarized signals.

5-3.3.7.4 Dipole antenna.- The dipole antenna shall consist of two elements of minimum length constructed of Monel metal or stainless steel. The elements shall have a smooth unpainted finish. If the antenna elements are adjustable, then they shall be adjustable by utilizing a fixed segment Of 1/2 inch diameter (minimum) and a collet segment that slides over the fixed segment. The fixed segments shall be assembled directly to the sides of the housing. The free end of each collet segment may be closed by an end-loading disc of 3 inches maximum diameter. There shall be positive locking of the collet segment onto the fixed segment without disturbing the selected setting.

5-3.3.7.5 Antenna mast.- The antenna masts shall be constructed to extend 48 to 50 inches below the antenna. The lower 3-inch portion of the mast shall have an outside diameter of 1.315 inches, and this portion shall be provided with standard l-inch tapered pipe thread. A standard l-inch I.P.S. threaded metallic pipe coupling, 1-3/4 inches long, shall be provided on the lower end of the mast. The pipe coupling shall be fabricated from stainless steel or a metallic nonferrous material (aluminum alloy not acceptable) such that it can be repeatedly attached to and detached from the mast by hand. This shall be possible without the need to apply a lubricant between coupling and mast surfaces.

5-3.3.7.5.1 Mast surface.- The mast surface shall be thoroughly cleaned and given an anodic or similar treatment to obtain a dense adherent coating of aluminum oxide, and then shall be given at least two coats of insignia white enamel, baked on, color 17875 in accordance with Federal Standard 595.

5-3.3.7.5.2 Mast cable slot.- The mast shall be provided with a slot located 35 to 40 inches below the antenna. The slot shall be of sufficient size to permit passage of the coaxial cable with terminating plug attached.

5-3.3.7.5.3 Cable clamp.- Suitable means shall be provided for clamping the cable within the monitor antenna housing or mast to prevent damage due to strain.

5-3.3.7.6 Protective enclosure.- A plastic enclosure fabricated from fiberglass reinforced material shall be provided to prevent birds, insects, ice, snow, and rain from coming in contact with the antenna elements. Requirements for the plastic enclosure shall be in accordance with the following paragraphs of Specification FAA-E-1069 and supplement No. 1: 3.1 through 3.2.7. The plastic enclosure shall have a cross-section shaped in the form of an inverted U with the curved portion having a 180 degree radius not less than 6 inches. The plastic enclosure shall be closed at the ends and shall have a bottom which is easily removable. The plastic enclosure shall be assembled and fastened to the mast in such a manner that the required protection is afforded the antenna elements. No part of the plastic enclosure surface shall make contact with the antenna elements, and to protect against detuning which may be caused by birds alighting on the plastic enclosure, the spacing between antenna elements and plastic enclosure shall be at least 4 inches. The plastic enclosure shall be designed for easy disassembly to provide access to the antenna elements for maintenance and repairs. A vertical portion of the enclosure shall begin a minimum of 1 inch above the elements. The enclosure shall be connected to the "U" shaped section by means of a vertical flange.

5-3.3.7.6.1 Environmental test method.- The monitor antenna shall be tested in accordance with Method 506.1, "Rain", of MIL-STD-810, Procedure 1.

5-3.3.7.7 Nameplate.- A nameplate shall be provided and mounted on the outside surface of the monitor antenna mast. The nameplate shall contain all the information required in FAA-G-2100, but the size shall be reduced proportionately to satisfactorily fit the mast.

5-3.3.7.7.1 Equipment title.- The equipment title for the nameplate shall be: VOR MONITOR ANTENNA.

5-3.3.7.8 Monitor antenna extension mast.- The monitor antenna extension mast shall consist of two sections of standard l-inch I.P.S. aluminum pipe, each 48 to 50 inches long, and a standard l-inch I.P.S. threaded metallic pipe coupling 1 3/4 inches long. One extension section shall be threaded only at one end. Standard tapered threads shall be used.

5-3.3.7.9 Monitor antenna/monitor interconnecting cables.- The monitor antenna output shall be connected to the monitor by means of an odd number multiple of quarter-wavelength RG-223/U coaxial cable fitted with TNC type connectors. System performance requirements of the monitor equipment specified herein shall be met with an interconnecting cable of up to 45 feet in length between the monitor antenna and monitor switch, and 400 feet between the monitor antenna switch and the monitor.

5-3.3.8 Monitor.- The monitor shall be a unit containing the necessary circuits:

(a) to accept the RF signal from the antenna switch and simulated VOR signals

(b) to differentiate between the various applied signals

(c) to provide for the application of the audio signals to other external equipment

(d) to monitor the level of the FM subcarrier and 30 Hz AM signals, keying of the 1020 Hz identification, the relative field intensity, the FM deviation ratio, and the azimuth of the monitor antenna

(e) to indicate whether its signals are within or exceed established limits, and, in the latter case, to initiate corrective action by actuating external equipment

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(e) to indicate whether its signals are within or exceed established limits, and, in the latter case, to initiate corrective action by actuating external equipment

300 to 3000 Within ±2.5 (referred to 1000 Hz)

5-3.3.8.3.5 Audio distortion.- The total harmonic distortion in the range of 300 Hz to 3000 Hz shall not exceed 4 percent at rated output.

5-3.3.8.3.6 Hum and noise.- The total hum and noise level shall not exceed -24 dBm at all settings of the level control.

5-3.3.8.3.7 Headphone output.- The audio signals from the aural output shall be applied to a 1/4 inch phone jack, which shall be provided on the front panel of the monitor, marked AUDIO, for use in checking station identification and voice signals with headphones, and shall meet the requirements of the following subparagraph: A mating plug shall be provided with the phone jack.

5-3.3.8.3.7.1 Output power.- The output power at the phone jack, when terminated in a 20,000 ohm ±5 percent resistive load, shall be at least +4 dBm. Also, connecting a 20,000 ohm ±5 percent resistive load across the phone jack shall not cause a change in aural output at 1000 Hz at the rear terminals greater than 0.5 dB.

5-3.3.8.4 Isolation from 30 Hz AM signal.- The level of the 30 Hz AM signal in the 30 Hz FM channel shall be at least 60 dB below the level of 30 Hz AM at the output of the AM detector.

5-3.3.8.5 Detector signal harmonics.- The level of harmonics of the detected 30 Hz FM signal, as measured at the input of the stage following the detector, shall be at least 60 dB below the fundamental.

5-3.3.8.6 Azimuth selection circuit.- The requirements of the following subparagraphs shall apply to the azimuth selection circuit.

5-3.3.8.6.1 Azimuth selection.- It shall be possible to select the azimuth reference between 000.0 and 359.9 degrees in 0.1 degree increments via the FCPU to PMDT interface or the FCPU to RSCE interface (paragraphs 3-3.3.1.2.1 and 3-3.3.3.1.2.2 herein, respectively). This reference will be set only at the highest data access security level (paragraph 3-3.3.1.12).

5-3.3.8.7 Zero adjustment.- The VOR monitor microprocessor shall automatically compensate for the inherent phase difference between the two 30 Hz channels. The phase difference compensation shall be displayable as calibration readout via FCPU interface request.

5-3.3.8.8 Accuracy of azimuth indication.- The azimuth indication at the FCPU interfaces shall be accurate to within ±0.05 degree, readable to 0.1 degree for all azimuthal inputs.

5-3.3.8.8.1 Stability with changes in signal frequency.- The azimuth shall remain constant within ±0.1 degree with changes in frequency of the 30 Hz components of the input signals over the range of 29.7 to 30.3 Hz.

5-3.3.8.8.2 Stability with changes in AC line voltage.- The azimuth shall remain constant within ±0.1 degree with changes in AC line voltage (to the Battery Charger Power Supply) over the range of service conditions.

5-3.3.8.8.3 Stability with voice signals applied.- The azimuth shall remain constant within ±0.1 degree when any signals within the frequency range of 300 Hz to 3000 Hz are applied to the monitor simultaneously with the 30 Hz components of the input signal.

5-3.3.8.9 Fault circuits.- The requirements of the following subparagraphs shall apply to the fault circuits. Detection of the functions necessary to actuate the alarm circuits may be accomplished by means of electronic circuits.

5-3.3.8.9.1 Azimuth fault.- It shall be possible to set the azimuth fault limit between 0.1 and 1.9 degrees in 0.1 degree increments over the range from 000.0 through 359.9 degrees via the FCPU interfaces. This limit will be set only at the highest data access security level (paragraph 3-3.3.1.12). The measured azimuth shall be compared to the reference azimuth (5-3.3.8.6.1). When the magnitude of the difference between those two values exceeds the value of the azimuth fault limit, a fault condition shall exist.

5-3.3.8.9.2 30 Hz AM modulation fault.- It shall be possible to set the 30 Hz AM modulation reference point (nominal 30 percent) between 20 and 40 percent modulation and to set the 30 Hz AM modulation fault limit between 2 and 8 percent via the FCPU interfaces. The reference point and fault limit will be set only at the highest data access security level (paragraph 3-3.3.1.12). The measured 30 Hz modulation shall be compared to the 30 Hz AM modulation reference. When the measured value of the 30 Hz AM modulation differs from the reference point by a magnitude equal to or greater than the 30 Hz AM modulation fault limit, a fault condition shall exist.

5-3.3.8.9.3 FM Subcarrier modulation fault.- It shall be possible to set the FM subcarrier modulation reference point (nominal 30 percent) between 20 and 40 percent and to set the FM subcarrier modulation fault limit between 2 and 8 percent via the FCPU user interfaces. The reference point and the fault limit will be set only at the highest data access security level. The measured FM subcarrier modulation shall be compared to the FM subcarrier modulation reference. When the measured value of the FM subcarrier modulation differs from the reference by a magnitude equal to or greater than the FM subcarrier modulation fault limit, a fault condition shall exist.

5-3.3.8.9.4 FM subcarrier frequency deviation fault.- It shall be possible to set the maximum frequency deviation excursion reference point (nominal 480 Hz) of the 9960 Hz FM subcarrier between 424 and 536 Hz, and to set the FM subcarrier frequency deviation fault limit between 8 and 40 Hz in 8 Hz steps via the FCPU user interfaces. The reference point and the fault limit will be set only at the highest data access security level. The measured FM subcarrier frequency deviation shall be compared to the FM subcarrier frequency deviation reference to determine fault conditions.

5-3.3.8.9.5 Identification fault.- The system shall monitor the 1020 Hz identification signal. The monitored identification signal shall be compared with the identification code as set through the FCPU interfaces. When the monitored identification signal does not agree with the code as set through the FCPU interfaces, an alarm condition shall exist. Means shall be incorporated to preclude voice transmission from interfering with the identification monitor (paragraph 4-3.3.3.12.2.1).

5-3.3.8.9.6 Field intensity fault.- It shall be possible to set the nominal relative field intensity reference point and to set the relative field intensity fault limit between 1 and 9 dB via the FCPU interfaces. The reference point and the fault limit will be set only at the highest data access security level. The measured relative field intensity shall be compared to the reference field intensity. When the measured value of the field intensity is less than the reference field intensity by a magnitude equal to or greater than the field intensity fault limit, a fault condition shall exist. The stability of the field intensity measurement shall be ±1.0 dB.

5-3.3.8.9.7 Main alarm output.- An alarm output circuit shall be provided to initiate shutdown of the VOR transmitter. An adjustable control shall be accessible from the FCPU interfaces to provide an alarm indication within 4 to 10 seconds of a fault condition. Once set, the alarm time shall remain constant within 0.1 second.

5-3.3.8.9.7.1 Alarm bypass control.- An alarm bypass control shall be provided and connected to prevent shutdown and remote indication of alarm, when activated. The bypass switch and an amber LED on the transmitter front panel shall indicate when the monitors are bypassed. The FCPU shall not override the action of the alarm bypass system. The bypass shall also be controlled by the FCPU. Indication of bypass condition shall be provided to the remote control site.

5-3.3.8.9.7.2 Auxiliary alarm input.- The monitor shall include a pair of input terminals such that external normally closed contacts will be connected in series with the alarm circuit described herein. Additional monitors (such as Doppler VOR sideband antenna monitor or frequency difference monitor or both, not required to be furnished) may be connected at Doppler VOR facilities, however, the terminals shall be short-circuited prior to equipment delivery.

5-3.3.8.9.8 Remote readout.- The following shall be remoted by the FCPU:

(a) azimuth to hundredths of a degree

(b) 30 Hz and FM subcarrier (9960 Hz) modulation to percent modulation

(c) 30 hz AM frequency to tenths of a cycle

(d) FM subcarrier frequency deviation to 5 Hz

(e) relative field intensity in tenths of decibels

(f) status of monitor alarm bypass

5-3.3.8.9.9 Fail-safe operation.- The monitor shall be designed to provide "fail-safe" operation, i.e., the requirements given in the following subparagraph shall be met.

5-3.3.8.9.9.1 Component failure.- Failure within the monitor(s) shall cause an alarm, or result in a phase shift of less than ±0.5 degree, and/or change in level of the 30 Hz AM or FM subcarrier amplitude modulations of less than ±5 percent of their preset value. In the latter case (i.e., phase shift of less than ±0.5 degree and/or change in modulation of less than ±5 percent), any additional changes in the phase shift between and/or modulation levels of the signals, applied to and within the monitor section, shall cause an alarm condition when the total change equals the preset limits.

5-3.3.8.9.10 Fault setting tolerances.- A fault shall be detected by the respective fault circuit when the parameter value increases or decreases beyond pre-set acceptable limits with the following tolerances:

Azimuth	±0.1 degree
30 Hz AM modulation	±1 percent
FM subcarrier modulation	±1 percent
FM subcarrier frequency deviation	±5 Hz
Field intensity	±1 dB

5-3.3.8.10 Keyer.- The keyer shall operate to key the 1020 Hz audio signal (see paragraph a-3.3.3.11) into the dot-dash characters of International Morse Code representing any three- or four-letter combination of the alphabet. The characters shall be programmable via the FCPU interfaces. The keyer shall be of digital design. The use of motor driven keying devices to create the keying impulses is not permitted.

5-3.3.8.10.1 Identification code characteristics.- The identification code characteristics shall conform to the following:

(a) The dots shall be of a duration between 100 milliseconds and 125 milliseconds. The dashes shall be of a duration three times that of the dots.

(b) The spacing between the dots and dashes of a code letter shall be equal to the duration of one dot within ±5 percent.

(c) The spacing between consecutive letters of the three- or four-letter identification code group shall be equal to the duration of three dots within +10 percent (plus tolerance only). Provision shall be included to program a space equal to five (5) dot lengths between the last two letters of the code group.

(d) The repetition rate for the three- or four-letter identification code group shall be eight times per minute (once in each 75-dot length interval), except as noted under paragraph 5-3.3.8.10.2.

5-3.3.8.10.2 Synchronization for associated equipment.- The keyer shall be programmed to operate in association with DME equipment such that every fourth identification cycle shall cause a keying synchronization impulse to be provided to the DME. The other identification cycles shall be for the VOR.

5-3.4 Reliability.- (See paragraph 1-3.4 of Part 1.)

5-4 QUALITY ASSURANCE.- (See paragraph 1-4 Part 1.)

5-5 PREPARATION FOR DELIVERY.- (See paragraph 1-5 Part 1.)

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

VOR/DME EQUIPMENT
PART 6 - DME TRANSPONDER EQUIPMENT

6-1 SCOPE - DME TRANSPONDER EQUIPMENT

6-1.1 Scope of Part 6.- This Part 6 is one of a group of specification documents under the basic heading "VOR/DME Equipment", each of which carries the basic number FAA-E-2678 together with an alpha revision letter and a slant line and number corresponding to the Part number. This Part 6 covers requirements for DME Transponder Equipment to be furnished as part of a set of equipment as defined in Part 1 of this specification.

6-1.2 Limitations of Part 6.- This Part 6 does not completely define the requirements for physical and electrical interface with other equipment elements covered under other parts of the specification, these being the responsibility of the contractor. Additionally, certain requirements are defined only through reference to other parts of the specification.

6-2 APPLICABLE DOCUMENTS.- (See paragraph 1-2 of Part 1.)

6-3 REQUIREMENTS

6-3.1 Equipment to be furnished by the contractor.- Each set of equipment shall be complete and in accordance with all specification requirements and shall be completely wired and ready for operation upon connections of power, external control cables, external antenna cable, and when interconnected with other equipment units comprising a set of ground station equipment as defined in paragraph 1-3.2.1 of Part 1 of this specification. Each set of equipment shall be tuned and adjusted for operation on a channel assigned in accordance with the provisions contained in the contract schedule prior to shipment (see Table I of Part 1 for channel frequencies and pairings).

6-3.1.1 DME.- Each DME shall consist of the components described in paragraphs 6-3.4 through 6-3.4.6.1.

6-3.2 Definitions.- (See also paragraph 1-3.1 of Part 1.)

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

VOR/DME EQUIPMENT
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6-3.1.1 DME.- Each DME shall consist of the components described in paragraphs 6-3.4 through 6-3.4.6.1.

6-3.2 Definitions.- (See also paragraph 1-3.1 of Part 1.)

6-3.2.1.5 Interrogation rate.- The pulse pair rate for each interrogation signal is not less than 10 nor more than 150 pulse pairs per second (pps).

6-3.2.2 Transponder reply delay time.- For the purposes of this specification, reply delay time is defined as the time in microseconds of all delay introduced by circuitry of the transponder equipment in transmitting a pair of reply pulses in response to an interrogation signal. The reply delay time is measured from the 50 percent maximum voltage amplitude point on the leading edge of the first constituent RF pulse of the interrogation pulse pair to the corresponding point on the first constituent RF pulse of the reply pulse pair. (Note that first pulse timing is involved which will require retention of the time of the 50 percent amplitude point of the leading edge of the first pulse pending decode or pulse spacing validation. The nominal values of reply delays are 50 microseconds for "X" channel and 56 microseconds for "Y" channel.)

6-3.2.3 Squitter.- Randomly occurring pulse pairs generated within the transponder as required to maintain a minimum output pulse count of 1350 ±150 pps. As the number of replies to aircraft interrogations increases, the number of squitter pulses is automatically reduced to maintain the minimum output pulse count at the specified level.

6-3.2.4 Automatic gain reduction (AGR).- A feature of the transponder which automatically reduces the sensitivity of the receiver to limit the number of replies to interrogations to a specified maximum (presently 1350 ±150 pps).

6-3.2.5 Receiver sensitivity.- That level of interrogation signal as measured at the antenna input terminals of the ground station transponder which results in 70 percent replies to the interrogation signal. The terms "receiver sensitivity" and "receiver threshold triggering level" are often used interchangeably. (See 6-3.2.6 below.)

6-3.2.6 Receiver threshold triggering level.- (See 6-3.2.5 above.) As used herein refers to the receiver sensitivity in the absence of traffic loading resulting in AGR or reduction in reply efficiency due to echo suppression blanking.

6-3.2.7 Reply efficiency.- The percentage of replies provided by the transponder to an interrogation signal of a given level. The maximum reply efficiency is limited by the number of receiver output pulses (squitter plus replies) and the receiver dead time.

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The following paragraphs identify requirements for the transponder equipment and associated circuitry.

6-3.4.1 Operating channels.- Transponders shall provide the specified performance on each of the channels and modes (X or Y) listed in Table I of Part 1 when the proper frequency channel is selected by means of the frequency synthesizer (paragraph 1-3.3.14 of Part 1). (Except as may be permitted in 6-3.4.1.1 and 6-3.4.1.2 below, no other action shall be required to change channels.)

6-3.4.1.1 Broadband operation.- One single design shall be utilized for each RF device to cover operation on any selected channel.

6-3.4.1.2 RF tuning.- Unless otherwise provided in the contract or request for proposal, each RF device shall be capable of operating on any channel assignment within its design range (6-3.4.1.1 above) without the need for retuning. A pre-selector (if used) shall be exempt from this requirement.

6-3.4.1.3 Channel frequency accuracy and stability.- (See paragraph 1-3.3.14.1 of Part 1.)

6-3.4.1.4 RF pulse parameters.- RF pulse parameters shall be based on linear detection of the RF envelope(s) of the pulses. Reply pulse spacing and shape shall be as measured at the output of the transmitter, and reply delay shall be measured as defined under 6-3.2.2. (While certain requirements on permitted variation and stability may be contained hereinafter under a specific functional heading most directly associated with the required performance, the stated requirement shall nevertheless apply to the transponder as a whole.)

6-3.4.2 Duplexer.- A duplexer shall be provided to permit simultaneous operation of the receiver and transmitter on a single antenna. The duplexer shall be of the passive type. No adjustment to the duplexer shall be required in order to achieve the performance required throughout the band of frequencies listed in Table I of Part 1.

6-3.4.3 Receiver and associated video circuitry.- All performance requirements specified hereinafter which involve interrogation signal(s) shall be met when the signals have any combination of characteristics defined under paragraphs 6-3.2.1 through 6-3.2.1.5 and, unless otherwise indicated, have any value from threshold triggering level to not less than -10 dBm as referenced to the transponder antenna transmission line connector.

6-3.4.3.1 Receiver bandwidth and stability.- The bandwidth of the receiver and the stability thereof shall be such that the threshold sensitivity is not reduced by more than 3 dB when the total receiver drift in either direction is added directly to an interrogation signal frequency deviation of 100 KHz in the opposite direction.

6-3.4.3.2 Receiver decoder.- The decoder shall decode and produce an output pulse from interrogation signal pulse pairs occurring at spacing within the range of:

(a) 12 ±0.5 microseconds for channel numbers ending in the suffix "X".

(b) 36 ±0.5 microseconds for channel numbers ending in the suffix "Y".

Decoding of a single pulse shall not occur.

6-3.4.3.3 Receiver dead time.- Each decoded pulse (6-3.4.3.2) shall result in the generation of a dead time interval during which time the transponder shall not reply to any other signals at any and all levels up to -10 dBm. The dead time interval shall be adjustable throughout the range of 50 to 150 microseconds. With the exception of the number of decoded receiver noise pulses permitted under 6-3.4.3.10, dead time shall only be generated by received and decoded interrogation pulse pairs.

6-3.4.3.4 Receiver recovery time.- The recovery time of the receiver and its associated video circuitry shall be such that the sensitivity to desired interrogations is not reduced by more than 2 dB when desired interrogations occur 8 microseconds (except 9 to 15 microseconds in X-mode, and 33 to 39 microseconds in Y-mode) and more after the reception of undesired pulses having all levels up to 60 dB above the sensitivity of the receiver in the absence of such undesired pulses. The desired interrogations shall be RF pulse pairs conforming to the characteristics specified in paragraph 6-3.2.1 through 6-3.2.1.5 and the undesired pulses shall conform to the same requirements except that the pulse spacing shall be outside the limits of 6-3.2.1.4 (such that dead time is not generated). The 8 microsecond spacing shall be measured between the 50 percent voltage point on the leading edge of the second pulse of the undesired pulse pair and the corresponding point on the leading edge of the first pulse of the desired pulse pair.

6-3.4.3.5 Echo suppression.- Echo suppression shall be provided in accordance with the following subparagraphs.

6-3.4.3.1 Receiver bandwidth and stability.- The bandwidth of the receiver and the stability thereof shall be such that the threshold sensitivity is not reduced by more than 3 dB when the total receiver drift in either direction is added directly to an interrogation signal frequency deviation of 100 KHz in the opposite direction.

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6-3.4.3.5 Echo suppression.- Echo suppression shall be provided in accordance with the following subparagraphs.

6-3.4.3.6 Station DME traffic load monitoring.- outputs shall be provided for local and remote monitoring of:

(a) The total number of decoded pulse pairs per second (total traffic).

(b) The number of echo suppression desensitization pulses (6-3.4.3.5) triggered per second (local or strong signal traffic).

6-3.4.3.7 Receiver sensitivity.- The receiver sensitivity for a reply efficiency of 70 percent shall be in accordance with the following subparagraphs. The measurements shall be referenced to the exterior cabinet connector to which the transmission line to the antenna is connected. (The values specified shall apply in the absence of automatic gain reduction [AGR], paragraph 6-3.4.3.12).

6-3.4.3.7.1 On-channel sensitivity.- For interrogation signals having a repetition rate of 30 pps and having spacings of the constituent pulses of a pair anywhere within the limits of paragraph 6-3.4.3.2, the receiver sensitivity in the absence of other interrogations, and with a dead time setting of 60 microseconds, shall be -94 dBm or better (i.e., the receiver threshold triggering level shall be -94 dBm or lower). (This value shall apply when the receiver gain control of paragraph 6-3.4.3.10 is set to allow the maximum permissible number of receiver noise decodes.) Once set within its range, sensitivity must be stable within ±1.0 dB (±2.0 dB over the service range of temperature). (See also 6-3.4.3.1.)

6-3.4.3.7.1.1 Variation with interrogation loading.- The sensitivity of the receiver shall not be reduced by more than 1 dB from the value measured in 6-3.4.3.7.1 in the presence of 2970 (3170 for "Y" channels) additional pps (or such higher number as may be required to provide 2500 ground station replies at an average reply efficiency of not less than 75 percent for "X" channels and 70 percent for "Y" channels) at a level of -70 dBm, with echo suppression circuits (6-3.4.3.5.2) disabled.

6-3.4.3.7.1.2 Triggering level at other pulse spacings.- The minimum triggering level for DME signal pulses having a spacing of the constituent pulse of a pair deviating from the design center value by ±3.0 microseconds and more shall be at least 70 dB higher than the value measured in 6-3.4.3.7.1 above.

6-3.4.3.7.1.3 Desensitization by adjacent channel interrogations.- The presence of interrogation signals at ±900 KHz from the on-channel frequencies which have pulse coding which

6-3.4.3.6 Station DME traffic load monitoring.- outputs shall be provided for local and remote monitoring of:

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6-3.4.3.7 Receiver sensitivity.- The receiver sensitivity for a reply efficiency of 70 percent shall be in accordance with the following subparagraphs. The measurements shall be referenced to the exterior cabinet connector to which the transmission line to the antenna is connected. (The values specified shall apply in the absence of automatic gain reduction [AGR], paragraph 6-3.4.3.12).

6-3.4.3.7.1 On-channel sensitivity.- For interrogation signals having a repetition rate of 30 pps and having spacings of the constituent pulses of a pair anywhere within the limits of paragraph 6-3.4.3.2, the receiver sensitivity in the absence of other interrogations, and with a dead time setting of 60 microseconds, shall be -94 dBm or better (i.e., the receiver threshold triggering level shall be -94 dBm or lower). (This value shall apply when the receiver gain control of paragraph 6-3.4.3.10 is set to allow the maximum permissible number of receiver noise decodes.) Once set within its range, sensitivity must be stable within ±1.0 dB (±2.0 dB over the service range of temperature). (See also 6-3.4.3.1.)

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6-3.4.3.7.1.2 Triggering level at other pulse spacings.- The minimum triggering level for DME signal pulses having a spacing of the constituent pulse of a pair deviating from the design center value by ±3.0 microseconds and more shall be at least 70 dB higher than the value measured in 6-3.4.3.7.1 above.

6-3.4.3.7.1.3 Desensitization by adjacent channel interrogations.- The presence of interrogation signals at ±900 KHz from the on-channel frequencies which have pulse coding which an interrogation pulse rise time of 0.10 (±0.10) microsecond.

(c) A total variation of 0.10 microsecond with an input signal level of minus (-) 60 dBm with a variation of interrogation pulse rise time through the range of 0.20 to 0.8 microsecond and a total variation of 0.5 microsecond through the range of 0.8 to 3.0 microseconds.

(d) A total variation of 0.10 microsecond with an input signal level of minus (-) 60 dBm with variation in interrogation pulse repetition frequency (PRF) from 25 through 4800 pps with an interrogation pulse rise time of 0.10 (±0.10) microsecond.

<u>6-3.4.3.7.4 Pulse width discrimination</u>.- The receiver shall provide a minimum of 70 dB of rejection to:

(a) Paired pulses of any spacing, including spacing within the range of 6-3.4.3.2, where either pulse has a width of 0.8 microsecond or less.

(b) Single pulses on any width including widths within the range of pulse spacings of 6-3.4.3.2.

<u>6-3.4.3.8 Reply efficiency</u>.- Two sets of performance requirements are specified below. The first (paragraph 6-3.4.3.8.1) applies when the transponder is operated to provide a maximum number of replies to interrogations of 2700 ±90 pulse pairs per second. The second (paragraph 6-3.4.3.8.2) applies when the transponder is operated to permit as many as 5000 replies to interrogations.

<u>6-3.4.3.8.1 Present duty cycle</u>.- In the absence of other interrogations, the receiver and its associated video circuitry shall provide a reply efficiency of not less than 85 percent (80 percent for "Y" channel) to the interrogation of a single aircraft (30 pps) when the level of interrogating signal is 10 dB above the threshold sensitivity level. In the presence of additional interrogations of 2970 pps (3170 for "Y" channel) having signal levels above the threshold sensitivity level, including levels as high as -70 dBm, the reply efficiency to the same single aircraft interrogation shall not be less than 75 percent (70 percent for "Y" channel) with a receiver dead time setting of 60 microseconds and with the echo suppression circuit (6-3.4.3.5.2) disabled. (For purposes of demonstration of compliance, the effect of the specified number of interrogations may be simulated through the use of one or more generators producing a total of 2500 decodes per second in the absence of other interrogations.)

an interrogation pulse rise time of 0.10 (±0.10) microsecond.

(c) A total variation of 0.10 microsecond with an input signal level of minus (-) 60 dBm with a variation of interrogation pulse rise time through the range of 0.20 to 0.8 microsecond and a total variation of 0.5 microsecond through the range of 0.8 to 3.0 microseconds.

(d) A total variation of 0.10 microsecond with an input signal level of minus (-) 60 dBm with variation in interrogation pulse repetition frequency (PRF) from 25 through 4800 pps with an interrogation pulse rise time of 0.10 (±0.10) microsecond.

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squitter triggers will be inhibited for all spacings of 25 microseconds and less for "X" channel and 65 microseconds and less for "Y" channel.

6-3.4.3.11 Pulse rate control.- The composite signal at the video output terminal of the priority gate circuitry (paragraph 6-3.4.3.10.1) shall consist of decoded interrogation pulses or squitter pulses, or both, in accordance with the following and paragraph 6-3.4.3.12. The squitter pulses from the separate squitter generator shall be automatically controlled in number as a function of interrogation signal loading (6-3.4.3.11.1). The output pulse spacing distribution of the separate squitter generator shall be essentially exponential with a minimum spacing of 60 microseconds. When the squitter pulse generator is providing output pulse pairs at the rate of 1350 ±150 (in the absence of decoded interrogation or receiver noise pulses) the output pulse pair spacing distribution shall be non-uniform with no pulse pairs spaced less than 60 microseconds apart.

6-3.4.3.11.1 Effect of traffic loading.- For all interrogation rates resulting in zero to 1500 receiver decodes per second, the squitter pulse generator shall produce not more than 1500-N pulses per second nor less than 1200-N pulses per second, where N is the number of receiver decodes. For all interrogation rates resulting in excess of 1500 receiver decodes per second, the squitter pulse generator shall produce no output.

6-3.4.3.12 Automatic gain reduction (AGR).- Under interrogation overload conditions in which the number of replies to interrogation signals tends to exceed 1350 pulse pairs per second, the receiver sensitivity shall be automatically reduced by the minimum amount necessary to maintain the transponder output pulse rate of 2700 (+150) pulse pairs per second. The available gain reduction shall not be less than 35 dB. The AGR circuit shall be adjustable (for future use...when increased traffic handling capacity may be required) to operate at any nominal level up to a transponder output pulse rate of 5000 (±150) pps.

6-3.4.3.12.1 Interrogation overload signal.- At all times that AGR is in operation, a signal shall be provided to the monitor(s) (Part 7 of this specification) in order to prevent receiver sensitivity alarms at times when the sensitivity has been deliberately reduced due to traffic overload.

6-3.4.4 Coder and associated circuitry.- Circuitry associated with the coder shall accomplish gating, timing, and coding of the distance reply and identity RF output signals produced by the transmitter. The coder shall utilize the decoded reply pulse (or squitter) outputs of the receiver (6-3.4.3) and Morse code keying from the operating VOR transmitter or from the DME keyer (6-3.4.5).

6-3.4.4.1 Priority of transmission.- The order of precedence for transmission of the output signal pulse shall be:

(1) Identity pulses.

(2) Distance reply or squitter pulse pairs.

Distance reply (or squitter) pulse pairs shall not be transmitted during the interval (Morse code dot or dash) of transmission of identification signal pulse groups.

6-3.4.4.2 Reply pulse coding.- Reply pulses shall be coded in pairs with a spacing as measured between the 50 percent maximum voltage amplitude point on the leading edge of the first RF pulse to the corresponding point on the leading edge of the second RF pulse, of (a) 12 (±0.25) microseconds for channel numbers ending in the suffix "X" or, (b) 30 (±0.25) microseconds for channel numbers ending in the suffix "Y".

6-3.4.4.3 Reply delay.- Means shall be provided to set the nominal reply delay time to within 0.0625 microsecond of any desired value between the limits of 35 to 51 microseconds on "X" channels (46 to 62 microseconds on "Y" channels).

6-3.4.4.4 Identification signal.- The identification signal shall consist of a group of two pulses at a basic repetition rate of 1350 ±10 pps. Each group shall consist of one pair of pulses spaced at 12 or 30 us (first pulse to first pulse). The time of occurrence of the identification groups shall be governed by the 1350 Hz tone generator. A separate, internal 1350 Hz source shall be provided. The internal source shall have a frequency and stability of 1350 ±5 Hz. The identification signal shall only be transmitted during periods of keying (Morse code dot or dash) provided by the external VOR keyer or by the internal DME keyer (6-3.4.5).

6-3.4.5 Identification keying.- Under normal operation, identification keying of the DME shall be accomplished by means of the identification keyer of the operating VOR equipment (see Parts 4 and 5 of this specification), resulting in keying of the DME during each fourth (see 5-3.3.8.10.2) cycle (approximately once each 30 seconds), during which keying of the VOR is omitted. In addition thereto, each DME equipment shall be provided with its own internal keyer to allow the DME to continue in operation upon failure of the VOR. In the event of shutdown of the VOR, the internal keyer shall automatically assume the keying the decoded reply pulse (or squitter) outputs of the receiver (6-3.4.3) and Morse code keying from the operating VOR transmitter or from the DME keyer (6-3.4.5).

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(1) Identity pulses.

(2) Distance reply or squitter pulse pairs.

Distance reply (or squitter) pulse pairs shall not be transmitted during the interval (Morse code dot or dash) of transmission of identification signal pulse groups.

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6-3.4.5 Identification keying.- Under normal operation, identification keying of the DME shall be accomplished by means of the identification keyer of the operating VOR equipment (see Parts 4 and 5 of this specification), resulting in keying of the DME during each fourth (see 5-3.3.8.10.2) cycle (approximately once each 30 seconds), during which keying of the VOR is omitted. In addition thereto, each DME equipment shall be provided with its own internal keyer to allow the DME to continue in operation upon failure of the VOR. In the event of shutdown of the VOR, the internal keyer shall automatically assume the keying output level within the range of 1000 watts to 250 watts or within the range of 100 watts to 25 watts directly from the FCPU interfaces. All transponder output signal requirements of paragraph 6-3.4.6.1.1 through 6-3.4.6.1.4 shall be met throughout the specified range of power output levels without the need for readjustment of any other controls.

6-3.4.6.1.5 Tuning and spurious output.- The tuning of all RF stages shall be straightforward and free of ambiguities. There shall be no spurious output or parasitic oscillations in any stage for any combination of tuning control positions with either normal or subnormal excitation conditions.

6-3.4.1.6 RF pulse signal spectrum.- The pulse signal spectrum of the transmitter output signal shall be such that the power contained in a 0.50 MHz band centered on frequencies 0.80 MHz above and below the nominal reply frequency is in each case at a level which is not less than 47 dB below the power contained in a 0.50 MHz band centered on frequencies 2.0 MHz above and below the nominal reply frequency shall in each case be at a level which is not less than 67 dB below the power contained in a 0.50 MHz band centered on the nominal reply frequency. All other like bands of the spectrum which are further removed from the reply frequency shall have lower levels of power threin than the adjacent band nearer the reply frequency. (The above dB ratios shall apply when the transponder is delivering 1000 watts of peak power. For any higher peak power output, the minimum dB ratios shall be increased proportionately, e.g., for an output power of 1250 watts the dB ratios shall be 48 and 68 dB in lieu of 47 dB and 67dB. Conversely, for the reduced power levels specified in paragraph 6-3.4.6.1.4 the dB ratios shall be reduced proportionately.)

6-3.4.6.1.7 Spurious output.- At all frequencies from 27 to 1660 MHz, but excluding the band of frequencies from 960 to 1215 MHz, the spurious output as measured at the antenna transmission line connector shall not exceed -40 dBm/KHz of receiver bandwidth. For purposes of determining compliance, measurement shall be made using a receiver having a 6 dB bandwidth not greater than 100 KHz. The equivalent isotropically radiated power of any CW harmonic of the carrier frequency on any DME operating channel shall not exceed -10 dBm. The level of harmonics and spurious radiation between 960 and 1215 MHZ, 2 MHZ removed from the assigned frequency, shall be at least 43 + 10 log (mean carrier power) decibels below the carrier, absolute level of 50 microwatts.

6-3.4.6.1.8 Inter-Pulse output level.- The RF output level during the interval between occurrence of the desired pulse pairs shall not exceed a level which is 80 dB below the output level within the range of 1000 watts to 250 watts or within the range of 100 watts to 25 watts directly from the FCPU interfaces. All transponder output signal requirements of paragraph 6-3.4.5.1.1 through 6-3.4.6.1.1.4 shall be met throughout the specified range of power output levels without the need for readjustment of any other controls.

6-3.4.6.1.5 Tuning and spurious output.- The tuninc of all RF stages shall be straightforward and free of ambiguities. There shall be no spurious output or parasitic oscillations in any stage for any combination of tuning control positions with either normal or subnormal excitation conditions.

6-3.4.1.6 RF pulse signal spectrum.- The pulse signal spectrum of the transmitter output signal shall be such that the power contained in a 0.50 MHz band centered on frequencies 0.80 MHz above and below the nominal reply frequency is in each case at a level which is not less than 47 dB below the power contained in a 0.50 MHz band centered on frequencies 2.0 MHz above and below the nominal reply frequency shall in each case be at a level which is not less than 67 dB below the power contained in a 0.50 MHz band centered on the nominal reply frequency. All other like bands of the spectrum which are further removed from the reply frequency shall have lower levels of power threin than the adjacent band nearer the reply frequency. (The above dB ratios shall apply when the transponder is delivering 1000 watts of peak power. For any higher peak power output, the minimum dB ratios shall be increased proportionately... e.g., for an output power of 1250 watts the dB ratios shall be 48 and 68 dB in lieu of 47 dB and 67dB. Conversely, for the reduced power levels specified in paragraph 6-3.4.6.1.4 the dB ratios shall be reduced proportionately.)

6-3.4.6.1.7 Spurious output.- At all frequencies from 27 to 1660 MHz, but excluding the band of frequencies from 960 to 1215 MHz, the spurious output as measured at the antenna transmission line connector shall not exceed -40 dBm/KHz of receiver bandwidth. For purposes of determining compliance, measurement shall be made using a receiver having a 6 dB bandwidth not greater than 100 KHz. The equivalent isotropically radiated power of any CW harmonic of the carrier frequency on any DME operating channel shall not exceed -10 dBm. The level of harmonics and spurious radiation between 960 and 1215 MHZ, 2 MHZ removed from the assigned frequency, shall be at least 43 + 10 log (mean carrier power) decibels below the carrier, absolute level of 50 microwatts.

6-3.4.6.1.8 Inter-Pulse output level.- The RF output level during the interval between occurrence of the desired pulse pairs shall not exceed a level which is 80 dB below the

DEPARTMENT OF TRANSPORTATION
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VOR/DME EQUIPMENT
PART 7 - DME MONITOR EQUIPMENT

7-1 SCOPE - DME MONITOR EQUIPMENT

7-1.1 Scope of Part 7.- This Part 7 is one of a group of specification documents under the basic heading "VOR/DME Equipment", each of which carries the basic number FAA-E-2678 together with an alpha revision letter and a slant line and number corresponding to the Part number. This Part 7 covers requirements for DME Monitor Equipment to be furnished as part of a set of equipment as defined in Part 1 of this specification.

7-1.2 Limitations of Part 7.- This Part 7 does not completely define the requirements for physical and electrical interface with other equipment elements covered under other parts of the specification, these being the responsibility of the contractor. Additionally, certain requirements are defined only through reference to other parts of the specification.

7-2 APPLICABLE DOCUMENTS.- (See paragraph 1-2 of Part 1.)

7-3 REQUIREMENTS

7-3.1 Equipment to be furnished by the contractor.- Each monitor shall be complete, functionally independent, and in accordance with all specification requirements. Each monitor shall be completely wired and ready for operation upon connection of power, external control cables, external antenna cable and when interconnected with other equipment units comprising a set of ground station equipment as defined in paragraph 1-3.2.1 of Part 1 of this specification. Each monitor shall be tuned and adjusted for operation on a channel assigned in accordance with the provisions contained in the contract schedule prior to shipment. (See Table I of Part 1 for channel frequencies and pairings.)

7-3.1.1 DME monitor.- Each DME monitor shall consist of the components described in paragraph 7-3.4 through 7-3.4.5.

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VOR/DME EQUIPMENT
PART 7 - DME MONITOR EQUIPMENT

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7-2 APPLICABLE DOCUMENTS.- (See paragraph 1-2 of Part 1.)

7-3 REQUIREMENTS

7-3.1 Equipment to be furnished by the contractor.- Each monitor shall be complete, functionally independent, and in accordance with all specification requirements. Each monitor shall be completely wired and ready for operation upon connection of power, external control cables, external antenna cable and when interconnected with other equipment units comprising a set of ground station equipment as defined in paragraph 1-3.2.1 of Part 1 of this specification. Each monitor shall be tuned and adjusted for operation on a channel assigned in accordance with the provisions contained in the contract schedule prior to shipment. (See Table I of Part 1 for channel frequencies and pairings.)

7-3.1.1 DME monitor.- Each DME monitor shall consist of the components described in paragraph 7-3.4 through 7-3.4.5.

(7-3.4.4) the frequency synthesizer shall also provide for outputs of ±200 KHz and ±900 KHz removed from the assigned channel interrogation frequency for test purposes.

7-3.4.1.1 Broadband operation.- Unless otherwise specified in the contract or request for proposal, one single design shall be utilized for each RF device to cover operation on any selected channel.

7-3.4.1.2 RF tuning.- Unless otherwise specified in the contract or request for proposal, each RF device shall be capable of operating on any channel assignment (7-3.4.1) without the need for retuning.

7-3.4.1.3 Channel frequency accuracy and stability.- (See paragraph 1-3.3.14.1 of Part 1.) The specified accuracy and stability shall apply identically to the selected channel and to the ±200 and ±900 KHz outputs of the interrogation Signal Generator (7-3.4.4).

7-3.4.1.4 RF pulse parameters.- (See paragraph 6-3.4.1.4 of Part 6.)

7-3.4.2 Monitor RF input and output signal coupling.-

7-3.4.2.1 Interrogation path.- Each monitor shall provide for interrogation of the transponder (normal unattended operation) for test purposes through command of the FCPU, Part 3 of the specification, via a (nominal) 30 dB directional coupler described in paragraph 7-3.4.2.3.

7-3.4.2.2 Reply path.-

7-3.4.2.2.1 Antenna transmission line/transponder output.- Most signal parameters (identified hereinafter) shall be monitored via the (nominal) 30 dB directional couplers described in paragraph 7-3.4.2.3. Each monitor shall provide for sampling the replies of the transponder (normal unattended operation) in response to the interrogations of the monitor (see 7-3.4.2.1 above).

7-3.4.2.2.1.1 RF input levels.- All monitor performance requirements shall be met when the transponder has any initial RF output power level of between 50 and 1000 watts peak (0.05 to 1 watt input to the monitor with nominal 30 dB coupling factor).

7-3.4.2.2.2 Radiated signal.- DME signal parameters (identified hereinafter) not monitored by means of directional couplers located in the antenna or transponder output transmission line (7-3.4.2.2.1 above) shall be monitored by means of signal coupling probes (two each) in

(7-3.4.4) the frequency synthesizer shall also provide for outputs of ±200 KHz and ±900 KHz removed from the assigned channel interrogation frequency for test purposes.

7-3.4.1.1 Broadband operation.- Unless otherwise specified in the contract or request for proposal, one single design shall be utilized for each RF device to cover operation on any selected channel.

7-3.4.1.2 RF tuning.- Unless otherwise specified in the contract or request for proposal, each RF device shall be capable of operating on any channel assignment (7-3.4.1) without the need for retuning.

7-3.4.1.3 Channel frequency accuracy and stability.- (See paragraph 1-3.3.14.1 of Part 1.) The specified accuracy and stability shall apply identically to the selected channel and to the ±200 and ±900 KHz outputs of the interrogation Signal Generator (7-3.4.4).

7-3.4.1.4 RF pulse parameters.- (See paragraph 6-3.4.1.4 of Part 6.)

7-3.4.2 Monitor RF input and output signal coupling.-

7-3.4.2.1 Interrogation path.- Each monitor shall provide for interrogation of the transponder (normal unattended operation) for test purposes through command of the FCPU, Part 3 of the specification, via a (nominal) 30 dB directional coupler described in paragraph 7-3.4.2.3.

7-3.4.2.2 Reply path.-

7-3.4.2.2.1 Antenna transmission line/transponder output.- Most signal parameters (identified hereinafter) shall be monitored via the (nominal) 30 dB directional couplers described in paragraph 7-3.4.2.3. Each monitor shall provide for sampling the replies of the transponder (normal unattended operation) in response to the interrogations of the monitor (see 7-3.4.2.1 above).

7-3.4.2.2.1.1 RF input levels.- All monitor performance requirements shall be met when the transponder has any initial RF output power level of between 50 and 1000 watts peak (0.05 to 1 watt input to the monitor with nominal 30 dB coupling factor).

7-3.4.2.2.2 Radiated signal.- DME signal parameters (identified hereinafter) not monitored by means of directional couplers located in the antenna or transponder output transmission line (7-3.4.2.2.1 above) shall be monitored by means of signal coupling probes (two each) in

NOTE 3: (g) shall utilize the output of the DME antenna coupling probes (7-3.4.2.2.2.1).

7-3.4.3.1 Executive monitor alarm action.- The following actions shall occur as the result of monitor alarms on key signal parameters of 7-3.4.3 above, subject to the requirements of paragraph 7-3.3.4 herein.

(1) Alarm on parameters (a), (b), (c), (d), or (f) of 7-3.4.3 shall result in transfer (if this is the first alarm) of redundant encoder circuitry, in the transponder (where so equipped), or in the shutdown of the DME (if this is the second alarm), as appropriate. (See paragraphs 1-3.1.14 and I-3.3.19 of Part 1.)

(2) Alarm on either parameters (e) or (g) shall result in shutdown of the DME.

7-3.4.3.2 Key parameter detailed requirements.-

7-3.4.3.2.1 Reply delay monitor.- The reply delay monitor shall measure the position of reply pulses transmitted in response to the higher-level outputs of the interrogation signal generator (paragraph 7-3.4.4). The fault threshold point shall be reached whenever the reply delay (6-3.2.3 of Part 6) deviates from its nominal setting by ±0.6 (±0.2) microsecond and more. The performance of the reply delay monitor shall not be sensitive to the interrogation rate of the monitor signal generator nor to the percentage of replies to monitor interrogation for reply efficiencies as low as 50 percent. The reply delay monitor shall, however, provide a count of the number of replies to monitor interrogation and provide a measure of reply efficiency for remote maintenance monitoring purposes. False alarm data collection may be inhibited during identification for a period of time not to exceed 5 seconds.

7-3.4.3.2.2 Output pulse spacing monitor.- The output pulse spacing monitor shall measure the spacing of the transponder output pulse pairs (6-3.4.4.2 of Part 6). The fault threshold shall be reached whenever the spacing deviates from the nominal value for the channel assigned (12.0 or 30.0 microseconds) by ±0.4 (±0.2) microsecond and more. False alarm data collection may be inhibited during identification for a period of time not to exceed 5 seconds.

7-3.4.3.2.3 Receiver sensitivity monitor.- The receiver sensitivity monitor shall measure the percentage of replies transmitted in response to the lower-level outputs of the interrogation signal generator (paragraph 7-3.4.4). The fault threshold level shall be adjustable between the limits of 50 to 70 percent. The adjustment shall either be continuous or in increments of not greater than 2.5 percent. Fault (and alarm) conditions shall be provided in accordance with the following.

(a) Within 15 seconds (90 percent confidence level) when the true reply efficiency is 10 percentage points below the threshold setting.

(b) Within 30 seconds (90 percent confidence level) when the true reply efficiency is 5 percentage points below the threshold setting.

(c) Within 30 seconds (50 percent confidence level) when the true reply efficiency is 2.5 percentage points below the threshold level.

(d) Not more frequently than once in 2.5 hours when the true reply efficiency is 2.5 percentage points above the threshold level.

(e) Not more frequently than once in 720 hours when the true reply efficiency is 5.0 percentage points above the threshold level.

Replies to interrogation shall be those replies falling within an acceptance gate adjustable to correspond to any nominal beacon reply delay setting in the range of paragraph 6-3.4.3.7.3 of Part 6. The width of the gate shall be not less than 3.0 microseconds nor greater than 5.0 microseconds. The position of the center of the gate shall not vary more than ±0.25 microsecond over the service conditions.

The receiver sensitivity monitor shall be bypassed (alarm feature disabled) at such times that the interrogation overload signal (paragraph 6-3.4.3.12.1 of Part 6) is being transmitted to the monitor from the operating transponder.

<u>7-3.4.3.2.4 Transponder output pulse rate monitor.</u>- A fault condition shall exist whenever the transponder output pulse rate decreases to 850 (±100) pps and lower values.

<u>7-3.4.3.2.5 Transponder power output monitor.</u>- The transponder power output monitor shall respond to the amplitude level of transponder output pulses as provided by the transmission line directional couplers (7-3.4.2.2.1 and 7-3.4.2.2.1.1). A fault threshold shall be reached whenever the peak power level of the signal decreased to any preselected level within -1.0 to -6.0 dB relative to any initial value of paragraph 7-3.4.2.2.1.1. The fault threshold point shall have a stability of ±0.5 dB. After the sensing of a fault, an increase of 0.5 dB in the

of 50 to 70 percent. The adjustment shall either be continuous or in increments of not greater than 2.5 percent. Fault (and alarm) conditions shall be provided in accordance with the following.

(a) Within 15 seconds (90 percent confidence level) when the true reply efficiency is 10 percentage points below the threshold setting.

(b) Within 30 seconds (90 percent confidence level) when the true reply efficiency is 5 percentage points below the threshold setting.

(c) Within 30 seconds (50 percent confidence level) when the true reply efficiency is 2.5 percentage points below the threshold level.

(d) Not more frequently than once in 2.5 hours when the true reply efficiency is 2.5 percentage points above the threshold level.

(e) Not more frequently than once in 720 hours when the true reply efficiency is 5.0 percentage points above the threshold level.

Replies to interrogation shall be those replies falling within an acceptance gate adjustable to correspond to any nominal beacon reply delay setting in the range of paragraph 6-3.4.3.7.3 of Part 6. The width of the gate shall be not less than 3.0 microseconds nor greater than 5.0 microseconds. The position of the center of the gate shall not vary more than ±0.25 microsecond over the service conditions.

The receiver sensitivity monitor shall be bypassed (alarm feature disabled) at such times that the interrogation overload signal (paragraph 6-3.4.3.12.1 of Part 6) is being transmitted to the monitor from the operating transponder.

<u>7-3.4.3.2.4 Transponder output pulse rate monitor</u>.- A fault condition shall exist whenever the transponder output pulse rate decreases to 850 (±100) pps and lower values.

<u>7-3.4.3.2.5 Transponder power output monitor</u>.- The transponder power output monitor shall respond to the amplitude level of transponder output pulses as provided by the transmission line directional couplers (7-3.4.2.2.1 and 7-3.4.2.2.1.1). A fault threshold shall be reached whenever the peak power level of the signal decreased to any preselected level within -1.0 to -6.0 dB relative to any initial value of paragraph 7-3.4.2.2.1.1. The fault threshold point shall have a stability of ±0.5 dB. After the sensing of a fault, an increase of 0.5 dB in the

measurement and certification of other specified performance characteristics of the transponder.

7-3.4.4.1 RF Output frequencies.- (See paragraphs 7-3.4.1 through 7-3.4.1.3.) The center frequency shall be used for normal monitoring purposes. The ±200 KHz frequencies shall be used for the testing of transponder receiver bandwidth (6-3.4.3.1 of Part 6) and the ±900 KHz frequencies shall be utilized for the testing of adjacent channel rejection (6-3.4.3.7.2 of Part 6).

7-3.4.4.2 RF pulse spectrum.- The RF spectrum of the signal generator output shall conform to the definition of paragraph 6-3.2.1.2 of Part 6.

7-3.4.4.3 Spurious output.- At all frequencies from 27 to 1600 MHz, but excluding the band of frequencies from 1023 to 1152 MHz, the spurious output as measured at the RF output connector of the signal generator shall not exceed -40 dBm/KHz of receiver bandwidth. In addition, the power at the RF output connector during the intervals between occurrence of the desired interrogation pulse pairs shall not exceed a level of -80 dBm for all settings of the output attenuator.

7-3.4.4.4 RF output pulse shape.- The RF output pulse shape shall conform to the definition of paragraphs 6-3.2.1.3 through 6-3.2.1.3.4 of Part 6, except that the pulse rise time (6-3.2.1.3.1) shall be 0.1 (±0.1) microsecond, and the pulse decay time (6-3.2.1.3.4) shall not be less than 0.0 microsecond, nor greater than 3.0 microseconds.

7-3.4.4.5 RF output pulse spacing.- In the normal mode of operation the signal generator output pulse spacing shall be in accordance with paragraph 6-3.2.1.4 of Part 6 except that the tolerance shall be ±0.2 microsecond in lieu of ±0.5 micro-second. For test purposes the spacing shall be capable of variation throughout the range of zero through +3.2 microseconds removed from the nominal assigned channel spacing in increments of not less than 0.1 microsecond nor greater than 0.2 microsecond.

7-3.4.4.6 RF output level.- The signal generator shall be capable of providing RF output pulse levels at the output connector throughout the range of 0 dBm through -80 dBm (-30 dBm through -110 dBm at the transponder receiver input) (see 7-3.4.2.1). A stability of ±1.0 dB shall apply to any selected output level. During normal monitoring operation the signal generator shall provide two fixed levels of output on a time sharing basis, a high level output for the monitoring of reply delay (7-3.4.3.2.1) and a lower level output for the monitoring of receiver sensitivity (7-3.4.3.2.3).

7-3.4.4.6.1 High output level.- The high output level shall be set at -30 dBm (-60 dBm at the transponder receiver input).

7-3.4.4.6.2 Low output level.- The low output level shall have a range of initial adjustment between -25 dBm and -80 dBm (-55 dBm and -110 dBm at the transponder input).

7-3.4.4.6.3 Test output levels.- During test operation the signal generator shall provide pulsed or CW outputs at the various levels required for the measurement of transponder receiver performance requirements of paragraphs 6-3.4.3.7.1, through 6-3.4.3.7.2 and 6-3.4.3.7.3 (b) and (d) of Part 6.

NOTE: During test operation the signal generator shall not be required to provide time shared outputs. Accomplishment of measurements corresponding to paragraphs 6-3.4.3.7.1.1, 6-3.4.3.7.1.3, and 6-3.4.3.7.1.4 presume the use of two signal generators and are therefore required in the dual monitor configuration.

7-3.4.4.7 Output PRF.- The output PRF in the normal monitor mode of operation shall not exceed 30 pps, of which up to 80 percent shall be permitted to be at the low output level (7-3.4.4.6.2) and as few as 20 percent shall be permitted to be at the high output level (7-3.4.4.6.1). In the test mode of operation for those measurements involving the percentage of replies to desired signals the number of interrogations shall not exceed 400 pps. For tests requiring the simulation of traffic loading or undesired off-channel pulses, the signal generator shall be capable of providing output pulse rates anywhere within the range of 10 through 10,000 pps. Output pulse pairs provided in this last mode of operation shall be random in occurrence (i.e., the pulse spacing distribution shall be approximately exponential).

7-3.4.5 Video pulse generator.- The video pulse generator shall provide simulated transponder output pulse pairs for alarm limit certification of the following monitored parameters:

(a) Reply delay (7-3.4.3.2.2).

(b) Reply pulse spacing (7-3.4.3.2.2).

(c) Receiver sensitivity (percent replies) (7-3.4.3.2.3).

(d) Output pulse rate (7-3.4.3.2.4).

7-3.4.4.6.1 High output level.- The high output level shall be set at -30 dBm (-60 dBm at the transponder receiver input).

7-3.4.4.6.2 Low output level.- The low output level shall have a range of initial adjustment between -25 dBm and -80 dBm (-55 dBm and -110 dBm at the transponder input).

7-3.4.4.6.3 Test output levels.- During test operation the signal generator shall provide pulsed or CW outputs at the various levels required for the measurement of transponder receiver performance requirements of paragraphs 6-3.4.3.7.1, through 6-3.4.3.7.2 and 6-3.4.3.7.3 (b) and (d) of Part 6.

NOTE: During test operation the signal generator shall not be required to provide time shared outputs. Accomplishment of measurements corresponding to paragraphs 6-3.4.3.7.1.1, 6-3.4.3.7.1.3, and 6-3.4.3.7.1.4 presume the use of two signal generators and are therefore required in the dual monitor configuration.

7-3.4.4.7 Output PRF.- The output PRF in the normal monitor mode of operation shall not exceed 30 pps, of which up to 80 percent shall be permitted to be at the low output level (7-3.4.4.6.2) and as few as 20 percent shall be permitted to be at the high output level (7-3.4.4.6.1). In the test mode of operation for those measurements involving the percentage of replies to desired signals the number of interrogations shall not exceed 400 pps. For tests requiring the simulation of traffic loading or undesired off-channel pulses, the signal generator shall be capable of providing output pulse rates anywhere within the range of 10 through 10,000 pps. Output pulse pairs provided in this last mode of operation shall be random in occurrence (i.e., the pulse spacing distribution shall be approximately exponential).

7-3.4.5 Video pulse generator.- The video pulse generator shall provide simulated transponder output pulse pairs for alarm limit certification of the following monitored parameters:

(a) Reply delay (7-3.4.3.2.2).

(b) Reply pulse spacing (7-3.4.3.2.2).

(c) Receiver sensitivity (percent replies) (7-3.4.3.2.3).

(d) Output pulse rate (7-3.4.3.2.4).

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

VOR/DME EQUIPMENT
PART 8 - DOPPLER VOR CONVERSION KIT

8-1 SCOPE - DOPPLER VOR CONVERSION KIT

8-1.1 Scope of Part 8.- This Part 8 is one of a group of specification documents under the basic heading "VOR/DME Equipment," each of which carries the basic number FAA-E-2678 together with an alpha revision letter and a slant line and number corresponding to the Part number. This Part 8 covers the requirements for a kit consisting of the hardware, firmware and software required to convert a conventional VOR of Parts 1 through 5 and Part 9 of this specification to the Doppler VOR configuration. The conversion kits shall be furnished in the quantity and time schedule as specified in the contract schedule.

8-1.2 Limitation of Part 8.- This Part 8 does not completely define the requirements for physical and electrical interface with other elements covered under other parts of this specification, these being the responsibility of the contractor. Additionally, certain requirements are defined only by reference to other parts of the specification.

8-2 APPLICABLE DOCUMENTS.- (See paragraph 1-2 of Part 1.)

8-3 REQUIREMENTS

8-3.1 Application.- This equipment is to be used by the Government to convert a conventional VOR (furnished under this specification) to Doppler VOR (DVOR) configuration if it is determined that siting problems are such as to preclude acceptable operation of the conventional VOR. The equipment to be furnished must directly interface with the existing conventional VOR. The transmitting antennas, coaxial cable and monitor antenna will be furnished by the Government. The conversion kits shall be provided, if ordered by the Government, in accordance with the contract schedule.

8-3.1.1 Equipment to be furnished by the contractor.- The DVOR conversion kit shall contain the equipment specified herein as well as the assemblies, sub-assemblies, modules,

DEPARTMENT OF TRANSPORTATION
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VOR/DME EQUIPMENT
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8-1.2 Limitation of Part 8.- This Part 8 does not completely define the requirements for physical and electrical interface with other elements covered under other parts of this specification, these being the responsibility of the contractor. Additionally, certain requirements are defined only by reference to other parts of the specification.

8-2 APPLICABLE DOCUMENTS.- (See paragraph 1-2 of Part 1.)

8-3 REQUIREMENTS

8-3.1 Application.- This equipment is to be used by the Government to convert a conventional VOR (furnished under this specification) to Doppler VOR (DVOR) configuration if it is determined that siting problems are such as to preclude acceptable operation of the conventional VOR. The equipment to be furnished must directly interface with the existing conventional VOR. The transmitting antennas, coaxial cable and monitor antenna will be furnished by the Government. The conversion kits shall be provided, if ordered by the Government, in accordance with the contract schedule.

8-3.1.1 Equipment to be furnished by the contractor.- The DVOR conversion kit shall contain the equipment specified herein as well as the assemblies, sub-assemblies, modules, 8-3.2.3 Distributor blending function.- The theoretical ideal of continuous physical rotation of an antenna (8-3.2.1) can only be approached when switching signals to a finite number of antennas.

In order to minimize harmonics produced by switching transients, it is necessary to control the amplitude of the signals fed to adjacent antennas in a complementary manner (see paragraph 8-3.3.3.1). For purposes of this specification, the "ideal" blending function waveform is defined as a cosine function raised to the 0.836 power.

8-3.3 General requirements.- Each Doppler VOR conversion kit furnished under this specification shall include the equipment, materials, hardware and software, with the exception of transmitting and monitoring antennas and coaxial cable, required to convert a conventional VOR of Parts 1 through 5 and Part 9 of this specification to a Doppler VOR configuration. The kit shall include the equipment and other items as specified in the following subparagraphs.

8-3.3.1 Conversion kit equipment characteristics.- The hardware equipment items furnished as part of the conversion kit shall comply with the applicable requirements of Part 1, paragraphs 1-3.3.1 through 1-3.3.19.

8-3.3.2 Doppler VOR (DVOR) sideband transmitter.- The DVOR sideband transmitter receives a sample signal from the VOR transmitter (paragraph 4-3.3.3.10.1) and provides two carrier suppressed pure sideband outputs which are nominally 9960 Hz above and 9960 Hz below the frequency of the VOR transmitter, respectively.

8-3.3.2.1 Power output.- The sideband transmitter shall be capable of providing at least 10 watts of CW power output of each sideband signal. The output power shall be adjustable throughout a range of at least 2.5 watts to 10 watts in 0.5 watt increments.

8-3.3.2.1.1 Power output stability and control.- The sideband power outputs shall automatically track the output power of the VOR transmitter to provide a constant depth of modulation. After initial setup, the accuracy of the tracking shall be within ± 0.25 dB for VOR transmitter power changes of ± 1.0 dB to - 3.0 dB. This requirements shall be met over the range of service conditions.

8-3.3.2.2 Output frequencies.- The sideband transmitter shall employ an automatic frequency control circuit or other means to ensure that the output frequencies are maintained at f_c ± 9960 Hz ± 1.0 Hz over the service conditions.

8-3.3.2.3 Output phase.- The phase of each sideband output signal shall be maintained such that over the service conditions there is no more than 12 degrees difference between the phase of the 9960 Hz beat produced by mixture of the sideband signal with the carrier reference signal and the phase of the 9960 Hz reference signal.

8-3.3.2.4 Output frequency and phase response time. - The requirements of 8-3.3.2.2 and 8-3.3.2.3 shall apply within 9 seconds after initial application of power. (The procedure of paragraph 4.11 of Specification FAA-G-2100 is modified to delete reference to "15 minutes" in Step c.)

8-3.3.2.5 9960 Hz reference frequency.- The equipment design shall incorporate a 9960 Hz reference frequency generator. At the contractor's option, the reference generator may be either of the tunable frequency or fixed frequency type. The tunable device shall be capable of adjustment to within 1.0 Hz and shall have a stability of ± 10 Hz over the range of service conditions. If the contractor elects to provide a fixed frequency device, the precision and stability shall be such as to provide an output frequency of 9960 Hz ± 1.0 Hz over the range of service conditions.

8-3.3.2.6 Output signal spectrum.- Spurious radiation components within specified frequency bands on either side of the fundamental shall not exceed the following levels:

Frequency Band	Level Below Fundamental
15 KHz through 18 KHz	15 dB
18 KHz through 27 KHz	32 dB
27 KHz through 37 KHz	52 dB
Above 37 KHz	62 dB

8-3.3.2.7 Carrier to sideband isolation.- The level of the carrier reference frequency in the output of either sideband output signal shall be at least 34 dB below the level of the sideband output signal.

8-3.3.2.8 Cross channel isolation.- The level of the upper sideband signal (USB) present in the output of the lower sideband signal (LSB) shall be at least 40 dB below the output level of the USB signal and vice versa.

8-3.3.2.9 Stray radiation.- With the transmitter operating at maximum output power (8-3.3.2.1), stray radiation shall not exceed a level of 14.0 microwatts effective radiated power. This requirement shall be met with the equipment in or out of its enclosure.

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of the 50 distributor antenna output connectors shall be constant ± 5.0 degrees over the service conditions.

8-3.3.3.4 RF output waveform. - For each of the four signals of 8-3.3.3.1, the difference in peak amplitude of the signals appearing at the 25 output connectors shall not exceed ± 0.2 dB. This requirement shall be met at all output connections with a VSWR of up to 2.5.

8-3.3.3.5 Switching isolation. - Output shall be applied to the designated antennas only during the specified intervals of normal switching or whenever continuous radiation is selected (8-3.3.3.1). During every other interval of the switching cycle and during the off condition, the level of output to any connector shall be at least 60 dB below the on signal level.

8-3.3.3.6 30 Hz audio frequency generator. - The audio signal generator shall provide a sinusoidal 30 Hz output signal for modulation of the carrier transmitter (see paragraphs 4-3.3.3.4, 4-3.3.3.7.1.1 and 4-3.3.3.7.2).

8-3.3.3.6.1 Frequency stability. - The stability of the 30 Hz frequency shall be as established by the master generator (8-3.3.3.7).

8-3.3.3.6.2 Phase stability. - For any initial setting of the phase adjust control (8-3.3.3.7.1), the variation in time of occurrence of the zero crossover of the 30 Hz signal with respect to the distributor switching sequence shall not exceed ± 0.2 electrical degrees of 30 Hz over the range of service conditions.

8-3.3.3.6.3 Output level and stability. - The output level shall be adjustable to the level required to modulate the carrier transmitter at any level between 25 and 35 percent in 1.0 percent increments. When initially established, the modulation percent shall not vary more than ± 1.0 percent over the range of service conditions.

8-3.3.3.7 Master generator oscillator. - A master generator shall be provided as the source of all timing functions required for operation of the equipment. At the option of the contractor, the reference oscillator may be either of the tunable frequency or fixed frequency type. The tunable oscillator shall be capable of adjustment to within ± 0.01 percent of its design center value and shall have a stability of ± 0.01 percent over the range of service conditions. The fixed frequency type shall provide an output frequency which is within ± 0.01 percent of its design center value over the range of service conditions.

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Paragraph 4-1.1 - Add the following sentence to the end of the paragraph: "This specification describes both conventional VOR transmitting equipment and Doppler VOR transmitting equipment. Doppler transmitter configurations include the Doppler sideband transmitter unit described in Part 8 of this specification but not the goniometer unit (paragraph 4-3.3.1.2), whereas conventional VOR transmitter configurations include the goniometer unit but not the Doppler VOR sideband transmitter."

8-3.4.4 Chancres to Specification FAA-E-2678c/5.-

a. Paragraph 5-1.b - Add the following sentence to the end of the paragraph: "This specification describes both Doppler VOR monitor equipment and conventional VOR monitor equipment. For Doppler VOR, the ground check function and components are not applicable, the field monitor antenna and coaxial cable feedline to the monitor are provided by the Government, the auxiliary alarm input function (paragraph 5-3.3.8.9.7.2) is used to work with specific contractor furnished sideband antenna monitoring circuits which will be installed during the conversion of a conventional VOR to a Doppler VOR configuration."

b. Paragraph 5-3.3.5 - Add the following two sentences to the end of this paragraph: "The RF field intensity and polarization requirements of this paragraph do not apply in the Doppler VOR configuration. The Doppler VOR monitor shall meet all performance requirements with an RF input signal as otherwise specified herein supplied from a 50 ohm source at amplitudes between 25 millivolts and 500 millivolts RMS."

c. Paragraph 5-3.3.8 - Delete the text of (a) and substitute the following therefore: "to accept the RF signal as specified in paragraph 5-3.3.5 as modified herein."

d. Add the following new paragraph: "5-3.3.8.9.3.1 Sideband antenna signal level fault.- In the Doppler VOR configuration, it shall be possible to set the sideband antenna signal level reference point (nominal odB) and to set the fault limit between -1.5 dB and -2.0 dB via the FCPU user interfaces. The reference point and the fault limit will be set only at the highest data access security level. The measured sideband antenna signal level shall be compared to the sideband antenna reference level. When the measured value of the sideband antenna signal level differs from the reference level by a magnitude equal to or

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DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

VOR/DME EQUIPMENT
PART 9 - REMOTE STATUS AND COMMUNICATIONS EQUIPMENT (RSCE)

9-1 SCOPE - REMOTE STATUS AND COMMUNICATIONS EQUIPMENT (RSCE)

9-1.1 Scope of Part 9.- This Part 9 is one of a group of specification documents under the basic heading VOR/DME equipment, each of which. carries the basic number FAA-E-2678 together with an alpha revision letter and a slant line and number corresponding to the Part number. This Part 9 of the specification covers the requirements for the remote status and communication equipment (RSCE) to be furnished as part of a set of equipment as defined in Part 1 of this specification (FAA-E-2678c/1).

The RSCE will be located at a. site remote from the facility and will provide VOR/DME operational status information and audio communications capability to operations personnel. It will provide an interface between the VOR/DME facility and the MPS.

9-1.2 Limitations of Part 9.- This Part 9 does not completely define the requirements for operation with other equipment elements covered under other parts of the specification, these being the responsibility of the designer of the complete system. Additionally, certain requirements are defined only through reference to other parts of the specification.

9-2 APPLICABLE DOCUMENTS.- (See paragraph 1-2 of Part 1.)

9-3 REQUIREMENTS

9-3.1 Equipment to be furnished by the contractor.-

9-3.1.1 ____ The following items shall be furnished for each facility.

Unit	Quantity
Communications unit	1
RSCE processing unit	1
VOR/DME status unit	1

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3.3.4 with no adverse effects. In this configuration the requirement for the ten ± 2 second delay referenced in paragraph 9-3.2.1.2 shall apply to the restoration of the voice signal to the second line after the PTT signal has been removed.

9-3.2.2 RSCE processing unit.- The RSCE processing unit shall detect the VOR/DME operational status information, process this information and provide the output to the VOR/DME status unit (9-3.4). The status unit may be remoted from the RSCE by up to 200 feet. All data shall be transmitted to the MPS via the RSCE to MPS interface.

The RSCE shall provide buffer and processing action in collecting input data at differing rates from the VOR/DME FCPU and the MPS and shall buffer the received data to a higher or lower rate, as appropriate.

9-3.2.2.1 RSCE interfaces.- The RSCE shall have the following interfaces and equipment provided by the contractor.

(a) Communications unit data interface (CU).- An interface shall be provided to the RSCE for the transfer of data between the RSCE and the CU (9-3.2.1).

(b) RSCE to FCPU interface.- The RSCE to FCPU interface shall be in accordance with EIA standard RS-232 wired as synchronous data terminal equipment (DTE). It shall interface via a contractor provided commercially available voice over data modem with the Government furnished 4-wire telephone line described in paragraph 1-3.3.13.1. The interface shall operate at a minimum rate of 1200 baud. The protocol used to control the interface shall be as specified in paragraph 3-3.3.1.4 herein.

(c) Maintenance processor subsystem (MPS) interface.- An EIA - RS-232 synchronous data terminal equipment (DTE) interface shall be provided. It shall interface through a contractor provided, commercially available modem to a Government furnished 4-wire, full duplex dedicated telephone line. The data rate on this interface shall automatically adjust to rates of 2400, 4800 and 9600 baud. The protocol used to control the MPS interface shall be as specified in paragrpah 3-3.3.1.4 herein.

The RSCE shall have sufficient operational redundancy such that a single component failure in the RSCE shall not cause a loss of status monitoring.

9-3.2.2.2 RSCE to MPS interface. - It shall be possible to connect as many as five RSCE units to the Government furnished 4-wire dedicated telephone line with each RSCE unit having a discreet VOR/DME system address. (See paragraph 3-3.3.17.7 herein).

9-3.3. Equipment Construction.-The RSCE shall be designed for mounting in a Government furnished standard 19 inch cabinet rack, Type I, of Specification FAA-E-163. The equipment shall be chassis mounted on a rack panel not exceeding the size of the E panel of Drawing D-21140 of Specification FAA-G-2300. The panel shall comply with the requirements of Specification FAA-G-2300 with respect to size, dimensioning tolerances, quality of materials and construction methods. Input and output connections shall be on the rear of the chassis.

9-3.4 VOR/DME status unit. -The VOR/DME status unit will be installed in a Government furnished console in the FAA Automated Flight Service Station (AFSS) operations room that may be remoted as much as 200 feet from the RSCE location. The interconnect cable (type of cable and connector to be specified by the contractor during the Preliminary Design Review.) is not to be furnished under this specification.

9-3.4.1 Functions. -The VOR/DME status unit shall provide the following functions:

a. Visual indication of the operational status of the VOR and DME subsystems by the use of green "normal" and red "alarm" indicator lights.

b. Visual indication of monitor "by pass" (1-3.1.10.9) of the VOR or DME monitors by the use of amber indicator lights.

c. An aural alarm which operates simultaneously with the operation of the red "alarm" lights to indicate an alarm condition of the VOR or DME subsystems (see paragraph 1-3.1.10.5). The frequency of the aural alarm signal shall not exceed 2000 Hz.

d. A momentary aural alarm silence switch.

e. A momentary push button to test the operability of all lamps.

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FAA-E-2678c
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U.S. Department of Transportation

Federal Aviation Administration

Specification

VOR/DME Equipment